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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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TITLE OF THE INVENTION (500 characters max)

MITOTIC KINESIN INHIBITORS

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ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification

Number of Pages

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Number of Sheets

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☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

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Respectfully submitted,

SIGNATURE

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In Duplicate

TITLE OF THE INVENTION
MITOTIC KINESIN INHIBITORS

BACKGROUND OF THE INVENTION

5 This invention relates to 4,5-dihydropyrazole derivatives that are inhibitors of mitotic kinesins, in particular the mitotic kinesin KSP, and are useful in the treatment of cellular proliferative diseases, for example cancer, hyperplasias, restenosis, cardiac hypertrophy, immune disorders and inflammation.

10 Among the therapeutic agents used to treat cancer are the taxanes and vinca alkaloids. Taxanes and vinca alkaloids act on microtubules, which are present in a variety of cellular structures. Microtubules are the primary structural element of the mitotic spindle. The mitotic spindle is responsible for distribution of replicate copies of the genome to each of the two daughter cells that result from cell division. It is presumed that disruption of the mitotic spindle by these drugs results in inhibition
15 of cancer cell division, and induction of cancer cell death. However, microtubules form other types of cellular structures, including tracks for intracellular transport in nerve processes. Because these agents do not specifically target mitotic spindles, they have side effects that limit their usefulness.

20 Improvements in the specificity of agents used to treat cancer is of considerable interest because of the therapeutic benefits which would be realized if the side effects associated with the administration of these agents could be reduced. Traditionally, dramatic improvements in the treatment of cancer are associated with identification of therapeutic agents acting through novel mechanisms. Examples of this include not only the taxanes, but also the camptothecin class of topoisomerase I
25 inhibitors. From both of these perspectives, mitotic kinesins are attractive targets for new anti-cancer agents.

30 Mitotic kinesins are enzymes essential for assembly and function of the mitotic spindle, but are not generally part of other microtubule structures, such as in nerve processes. Mitotic kinesins play essential roles during all phases of mitosis. These enzymes are "molecular motors" that transform energy released by hydrolysis of ATP into mechanical force which drives the directional movement of cellular cargoes along microtubules. The catalytic domain sufficient for this task is a compact structure of approximately 340 amino acids. During mitosis, kinesins organize microtubules into the bipolar structure that is the mitotic spindle. Kinesins mediate move-

ment of chromosomes along spindle microtubules, as well as structural changes in the mitotic spindle associated with specific phases of mitosis. Experimental perturbation of mitotic kinesin function causes malformation or dysfunction of the mitotic spindle, frequently resulting in cell cycle arrest and cell death.

5 Among the mitotic kinesins which have been identified is KSP. KSP belongs to an evolutionarily conserved kinesin subfamily of plus end-directed microtubule motors that assemble into bipolar homotetramers consisting of anti-parallel homodimers. During mitosis KSP associates with microtubules of the mitotic spindle. Microinjection of antibodies directed against KSP into human cells prevents
10 spindle pole separation during prometaphase, giving rise to monopolar spindles and causing mitotic arrest and induction of programmed cell death. KSP and related kinesins in other, non-human, organisms, bundle antiparallel microtubules and slide them relative to one another, thus forcing the two spindle poles apart. KSP may also mediate in anaphase B spindle elongation and focussing of microtubules at the
15 spindle pole.

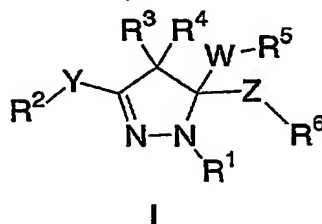
Human KSP (also termed HsEg5) has been described [Blangy, et al., Cell, 83:1159-69 (1995); Whitehead, et al., Arthritis Rheum., 39:1635-42 (1996); Galgio et al., J. Cell Biol., 135:339-414 (1996); Blangy, et al., J Biol. Chem., 272:19418-24 (1997); Blangy, et al., Cell Motil Cytoskeleton, 40:174-82 (1998);
20 Whitehead and Rattner, J. Cell Sci., 111:2551-61 (1998); Kaiser, et al., JBC 274:18925-31 (1999); GenBank accession numbers: X85137, NM004523 and U37426], and a fragment of the KSP gene (TRIP5) has been described [Lee, et al., Mol Endocrinol., 9:243-54 (1995); GenBank accession number L40372]. Xenopus KSP homologs (Eg5), as well as Drosophila K-LP61 F/KRP 130 have been reported.
25 Certain quinazolinones have recently been described as being inhibitors of KSP (PCT Publ. WO 01/30768, May 3, 2001).

Mitotic kinesins are attractive targets for the discovery and development of novel mitotic chemotherapeutics. Accordingly, it is an object of the present invention to provide compounds, methods and compositions useful in the inhibition
30 of KSP, a mitotic kinesin.

SUMMARY OF THE INVENTION

The present invention relates to 4,5-dihydropyrazole derivatives, that are useful for treating cellular proliferative diseases, for treating disorders associated

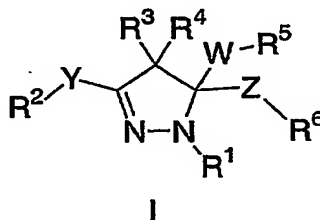
with KSP kinesin activity, and for inhibiting KSP kinesin. The compounds of the invention may be illustrated by the Formula I:



5

DETAILED DESCRIPTION OF THE INVENTION

The compounds of this invention are useful in the inhibition of mitotic kinesins and are illustrated by a compound of Formula I:



10

or a pharmaceutically acceptable salt or stereoisomer thereof, wherein

a is 0 or 1;

15 b is 0 or 1;

m is 0, 1, or 2;

n is 0 to 2;

u is 2, 3, 4 or 5;

20 R¹ is selected from:

- 1) (C=X)C₁-C₁₀ alkyl,
- 2) (C=X)aryl,
- 3) (C=X)C₂-C₁₀ alkenyl,

- 4) (C=X)C₂-C₁₀ alkynyl,
- 5) (C=X)C₃-C₈ cycloalkyl,
- 6) (C=X)heterocyclyl,
- 7) (C=X)NR⁷R⁸,
- 5 8) (C=X)OC₁-C₁₀ alkyl,
- 9) SO₂NR⁷R⁸,
- 10) SO₂C₁-C₁₀ alkyl,
- 11) SO₂C₁-C₁₀ aryl,
- 12) SO₂C₁-C₁₀ heterocyclyl,
- 10 13) C₁-C₁₀ alkyl,
- 14) aryl,
- 15) heteroaryl,
- 16) (CH₂)_u(C=O)C₁-C₁₀ alkyl,
- 17) (CH₂)_u(C=O) NR⁷R⁸,
- 15 18) 3-pyrrolidinonyl, 3-piperidinonyl, 2-cyclopentanonyl, 2-cyclohexanonyl,
- 19) (C=O)(C=O)C₁-C₁₀ alkyl,
- 20) (C=O)(C=O)NR⁷R⁸,
- 21) (C=O)(C=O)O C₁-C₁₀ alkyl,
- 20 said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, heteroaryl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; or

R² is selected from:

- 1) C₁-C₁₀ alkyl,
- 25 2) aryl,
- 3) C₂-C₁₀ alkenyl,
- 4) C₂-C₁₀ alkynyl,
- 5) C₁-C₆ perfluoroalkyl,
- 6) C₁-C₆ aralkyl,
- 30 7) C₁-C₆ heteroaralkyl,
- 8) C₃-C₈ cycloalkyl, and
- 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl, heteroaralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

R³, R⁴, R⁵ and R⁶ are independently selected from:

- 1) H,
- 2) C₁-C₁₀ alkyl,
- 5 3) aryl,
- 4) C₂-C₁₀ alkenyl,
- 5) C₂-C₁₀ alkynyl,
- 6) C₁-C₆ perfluoroalkyl,
- 7) C₁-C₆ aralkyl,
- 10 8) C₃-C₈ cycloalkyl, and
- 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; or

- 15 R³ and R⁴, or R⁵ and R⁶, attached to the same carbon atom (W and Z are a bond) are combined to form -(CH₂)_u- wherein one of the carbon atoms is optionally replaced by a moiety selected from O, S(O)_m, -N(R⁹)C(O)-, and -N(COR¹⁰)-;

R⁷ is:

- 20 1) (C=O)_aO_bC₁-C₁₀ alkyl,
- 2) (C=O)_aO_baryl,
- 3) C₂-C₁₀ alkenyl,
- 4) C₂-C₁₀ alkynyl,
- 5) (C=O)_aO_b heterocyclyl,
- 25 6) CO₂H,
- 7) halo,
- 8) CN,
- 9) OH,
- 10) O_bC₁-C₆ perfluoroalkyl,
- 30 11) O_a(C=O)_bNR⁹R¹⁰,
- 12) S(O)_mR^a,
- 13) S(O)₂NR⁹R¹⁰,
- 12) oxo,
- 13) CHO,

- 14) $(\text{N}=\text{O})\text{R}^9\text{R}^{10}$, or
 15) $(\text{C}=\text{O})_a\text{O}_b\text{C}_3\text{-C}_8$ cycloalkyl,

said alkyl, aryl, alkenyl, alkynyl, heterocyclyl, and cycloalkyl optionally substituted with one or more substituents selected from R^8 ;

5

R^8 is selected from:

- 1) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_1\text{-C}_{10})$ alkyl, wherein r and s are independently 0 or 1,
 2) $\text{O}_r(\text{C}_1\text{-C}_3)$ perfluoroalkyl, wherein r is 0 or 1,
 3) $(\text{C}_0\text{-C}_6)$ alkylene- $\text{S}(\text{O})_m\text{R}^a$, wherein m is 0, 1, or 2,
 10 4) oxo,
 5) OH,
 6) halo,
 7) CN,
 8) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_2\text{-C}_{10})$ alkenyl,
 15 9) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_2\text{-C}_{10})$ alkynyl,
 10) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_3\text{-C}_6)$ cycloalkyl,
 11) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)$ alkylene-aryl,
 12) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)$ alkylene-heterocyclyl,
 13) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)$ alkylene- $\text{N}(\text{R}^b)_2$,
 20 14) $\text{C}(\text{O})\text{R}^a$,
 15) $(\text{C}_0\text{-C}_6)$ alkylene- CO_2R^a ,
 16) $\text{C}(\text{O})\text{H}$,
 17) $(\text{C}_0\text{-C}_6)$ alkylene- CO_2H ,
 18) $\text{C}(\text{O})\text{N}(\text{R}^b)_2$,
 25 19) $\text{S}(\text{O})_m\text{R}^a$, and
 20) $\text{S}(\text{O})_2\text{NR}^9\text{R}^{10}$

said alkyl, alkenyl, alkynyl, cycloalkyl, aryl, and heterocyclyl is optionally substituted with up to three substituents selected from R^b , OH, $(\text{C}_1\text{-C}_6)$ alkoxy, halogen, CO_2H , CN, $\text{O}(\text{C}=\text{O})\text{C}_1\text{-C}_6$ alkyl, oxo, and $\text{N}(\text{R}^b)_2$;

30

R^9 and R^{10} are independently selected from:

- 1) H,
 2) $(\text{C}=\text{O})\text{O}_b\text{C}_1\text{-C}_{10}$ alkyl,
 3) $(\text{C}=\text{O})\text{O}_b\text{C}_3\text{-C}_8$ cycloalkyl,

- 4) (C=O)O^baryl,
 5) (C=O)O^bheterocyclyl,
 6) C₁-C₁₀ alkyl,
 7) aryl,
 5 8) C₂-C₁₀ alkenyl,
 9) C₂-C₁₀ alkynyl,
 10) heterocyclyl,
 11) C₃-C₈ cycloalkyl,
 12) SO₂R^a, and
 10 13) (C=O)NR^b₂,

said alkyl, cycloalkyl, aryl, heterocyclyl, alkenyl, and alkynyl is optionally substituted with one or more substituents selected from R⁸, or

- R⁹ and R¹⁰ can be taken together with the nitrogen to which they are attached to
 15 form a monocyclic or bicyclic heterocycle with 5-7 members in each ring and optionally containing, in addition to the nitrogen, one or two additional heteroatoms selected from N, O and S, said monocyclic or bicyclic heterocycle optionally substituted with one or more substituents selected from R⁸;

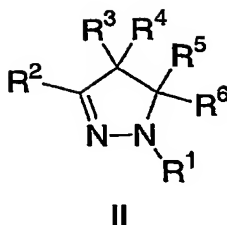
- 20 R^a is (C₁-C₆)alkyl, (C₃-C₆)cycloalkyl, aryl, or heterocyclyl; and

R^b is H, (C₁-C₆)alkyl, aryl, heterocyclyl, (C₃-C₆)cycloalkyl, (C=O)OC₁-C₆ alkyl, (C=O)C₁-C₆ alkyl or S(O)₂R^a;

- 25 X is selected from O and S;

Y, W and Z are independently selected from: a bond, C=O, C=S, S(O)_n, CH(OH) and O.

- 30 A further embodiment of the present invention is illustrated by a compound of Formula II, or a pharmaceutically acceptable salt or stereoisomer;



wherein:

- a is 0 or 1;
 5 b is 0 or 1;
 m is 0, 1, or 2;
 n is 0 to 2;

R¹ is selected from:

- 10 1) (C=O)C₁-C₁₀ alkyl,
 2) (C=O)aryl,
 3) (C=O)C₂-C₁₀ alkenyl,
 4) (C=O)C₂-C₁₀ alkynyl,
 5) (C=O)C₃-C₈ cycloalkyl,
 15 6) (C=O)heterocyclyl,
 7) (C=O)OC₁-C₁₀ alkyl,
 8) (C=O)NR⁷R⁸,
 9) SO₂NR⁷R⁸,
 10) SO₂C₁-C₁₀ alkyl,
 20 11) SO₂C₁-C₁₀ aryl,
 12) SO₂C₁-C₁₀ heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; or

25 R² is selected from:

- 1) C₁-C₁₀ alkyl,
 2) aryl,
 3) C₂-C₁₀ alkenyl,
 4) C₂-C₁₀ alkynyl,

- 5) C₁-C₆ perfluoroalkyl,
- 6) C₁-C₆ aralkyl,
- 7) C₃-C₈ cycloalkyl, and
- 8) heterocyclyl,

5 said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

R³, R⁴, R⁵ and R⁶ are independently selected from:

- 1) H,
- 10 2) C₁-C₁₀ alkyl,
- 3) aryl,
- 4) C₂-C₁₀ alkenyl,
- 5) C₂-C₁₀ alkynyl,
- 6) C₁-C₆ perfluoroalkyl,
- 15 7) C₁-C₆ aralkyl,
- 8) C₃-C₈ cycloalkyl, and
- 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

20 R⁷ is:

1. (C=O)_aO_bC₁-C₁₀ alkyl,
2. (C=O)_aO_baryl,
3. C₂-C₁₀ alkenyl,
- 25 4. C₂-C₁₀ alkynyl,
5. (C=O)_aO_b heterocyclyl,
6. CO₂H,
7. halo,
8. CN,
- 30 9. OH,
10. O_bC₁-C₆ perfluoroalkyl,
11. O_a(C=O)_bNR⁹R¹⁰,
12. S(O)_mR^a,
13. S(O)₂NR⁹R¹⁰,

14. oxo,
15. CHO,
16. (N=O)R⁹R¹⁰, or
17. (C=O)_aO_bC₃-C₈ cycloalkyl,

5 said alkyl, aryl, alkenyl, alkynyl, heterocyclyl, and cycloalkyl optionally substituted with one, two or three substituents selected from R⁸;

R⁸ is selected from:

- 1) (C=O)_rO_s(C₁-C₁₀)alkyl, wherein r and s are independently 0 or 1,
- 10 2) O_r(C₁-C₃)perfluoroalkyl, wherein r is 0 or 1,
- 3) oxo,
- 4) OH,
- 5) halo,
- 6) CN,
- 15 7) (C₂-C₁₀)alkenyl,
- 8) (C₂-C₁₀)alkynyl,
- 9) (C=O)_rO_s(C₃-C₆)cycloalkyl,
- 10) (C=O)_rO_s(C₀-C₆)alkylene-aryl,
- 11) (C=O)_rO_s(C₀-C₆)alkylene-heterocyclyl,
- 20 12) (C=O)_rO_s(C₀-C₆)alkylene-N(R^b)₂,
- 13) C(O)R^a,
- 14) (C₀-C₆)alkylene-CO₂R^a,
- 15) C(O)H,
- 16) (C₀-C₆)alkylene-CO₂H, and
- 25 17) C(O)N(R^b)₂,
- 18) S(O)_mR^a, and
- 19) S(O)₂NR⁹R¹⁰

30 said alkyl, alkenyl, alkynyl, cycloalkyl, aryl, and heterocyclyl is optionally substituted with up to three substituents selected from R^b, OH, (C₁-C₆)alkoxy, halogen, CO₂H, CN, O(C=O)C₁-C₆ alkyl, oxo, and N(R^b)₂;

R⁹ and R¹⁰ are independently selected from:

- 1) H,

- 2) (C=O)O^bC₁-C₁₀ alkyl,
 3) (C=O)O^bC₃-C₈ cycloalkyl,
 4) (C=O)O^baryl,
 5) (C=O)O^bheterocyclyl,
 5 6) C₁-C₁₀ alkyl,
 7) aryl,
 8) C₂-C₁₀ alkenyl,
 9) C₂-C₁₀ alkynyl,
 10) heterocyclyl,
 10 11) C₃-C₈ cycloalkyl,
 12) SO₂R^a, and
 13) (C=O)NR^b₂,

said alkyl, cycloalkyl, aryl, heterocyclyl, alkenyl, and alkynyl is optionally substituted with one, two or three substituents selected from R⁸, or

15 R⁹ and R¹⁰ can be taken together with the nitrogen to which they are attached to form a monocyclic or bicyclic heterocycle with 5-7 members in each ring and optionally containing, in addition to the nitrogen, one or two additional heteroatoms selected from N, O and S, said monocyclic or bicyclic heterocycle optionally
 20 substituted with one, two or three substituents selected from R⁸;

R^a is (C₁-C₆)alkyl, (C₃-C₆)cycloalkyl, aryl, or heterocyclyl; and

25 R^b is H, (C₁-C₆)alkyl, aryl, heterocyclyl, (C₃-C₆)cycloalkyl, (C=O)OC₁-C₆ alkyl, (C=O)C₁-C₆ alkyl or S(O)₂R^a.

Another embodiment is the compound of the Formula II described immediately above, or a pharmaceutically acceptable salt or stereoisomer thereof, wherein:

30 R¹ is selected from:

- 1) (C=O)C₁-C₁₀ alkyl,
 2) (C=O)aryl,
 3) (C=O)C₃-C₈ cycloalkyl,

- 3) (C=O)heterocyclyl,
- 4) (C=O)OC₁-C₁₀ alkyl,
- 5) SO₂NR⁷R⁸, and
- 6) SO₂C₁-C₁₀ alkyl,

5 said alkyl, aryl, cycloalkyl, and heterocyclyl is optionally substituted with one, two or three substituents selected from R⁷;

R² is selected from:

- 1) C₁-C₁₀ alkyl,
- 10 2) aryl, and
- 3) heteroaryl,

said alkyl, aryl and heteroaryl is optionally substituted with one or more substituents selected from R⁷;

15 R³ and R⁴ are independently selected from:

- 1) H, and
- 2) C₁-C₁₀ alkyl,

said alkyl is optionally substituted with one or more substituents selected from R⁷; and

20

R⁵ and R⁶ are independently selected from:

- 1) H,
- 2) C₁-C₁₀ alkyl,
- 3) aryl, and
- 25 4) heterocyclyl,

said alkyl, aryl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; and

30

R⁷, R⁸, R⁹, R¹⁰, R^a and R^b are as described immediately above.

In another embodiment of the compounds of Formula II hereinabove, R⁵ and R⁶ are selected from phenyl or pyridyl, optionally substituted with one or two substituents selected from R⁷.

Another embodiment is the compound of the Formula II described immediately above, or a pharmaceutically acceptable salt or stereoisomer thereof, wherein R² is phenyl, optionally substituted with one or two substituents selected from R⁷.

5

Specific examples of the compounds of the instant invention include:

3-[1-acetyl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

10

3-[3-(2-chlorophenyl)-1-isobutyryl-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-acetyl-3-(2-chlorophenyl)-5-methyl-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

15

(+)-3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

(-)-3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

20

3-[1-Acetyl-3-(2-fluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-Acetyl-3-(3-bromophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-Acetyl-3-(2,3-dichlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

25

3-[1-Acetyl-3-(2,5-dichlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-Propionyl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

30

3-[1-Isobutyryl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

1-Acetyl-3-(2-chlorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole

1-Acetyl-3-(3-chlorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole

35

1-Acetyl-3-(2,5-difluorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole

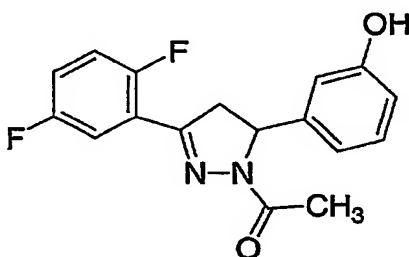
1-Acetyl-3-(4-fluoro-3-hydroxyphenyl)-5-phenyl-4,5-dihydro-1H-pyrazole

5 or a pharmaceutically acceptable salt or stereoisomer thereof.

A particular example of the compounds of the instant invention is:

3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

10



or a pharmaceutically acceptable salt or stereoisomer thereof.

15 The compounds of the present invention may have asymmetric centers, chiral axes, and chiral planes (as described in: E.L. Eliel and S.H. Wilen, *Stereochemistry of Carbon Compounds*, John Wiley & Sons, New York, 1994, pages 1119-1190), and occur as racemates, racemic mixtures, and as individual diastereomers, with all possible isomers and mixtures thereof, including optical
20 isomers, all such stereoisomers being included in the present invention. In addition, the compounds disclosed herein may exist as tautomers and both tautomeric forms are intended to be encompassed by the scope of the invention, even though only one tautomeric structure is depicted.

25 When any variable (e.g. R⁷, R⁸, R⁹, etc.) occurs more than one time in any constituent, its definition on each occurrence is independent at every other occurrence. Also, combinations of substituents and variables are permissible only if such combinations result in stable compounds. Lines drawn into the ring systems from substituents represent that the indicated bond may be attached to any of the substitutable ring atoms. If the ring system is polycyclic, it is intended that the

bond be attached to any of the suitable carbon atoms on the proximal ring only.

It is understood that substituents and substitution patterns on the compounds of the instant invention can be selected by one of ordinary skill in the art to provide compounds that are chemically stable and that can be readily synthesized by techniques known in the art, as well as those methods set forth below, from readily available starting materials. If a substituent is itself substituted with more than one group, it is understood that these multiple groups may be on the same carbon or on different carbons, so long as a stable structure results. The phrase "optionally substituted with one or more substituents" should be taken to be equivalent to the phrase "optionally substituted with at least one substituent" and in such cases the preferred embodiment will have from zero to three substituents.

As used herein, "alkyl" is intended to include both branched and straight-chain saturated aliphatic hydrocarbon groups having the specified number of carbon atoms. For example, C₁-C₁₀, as in "C₁-C₁₀ alkyl" is defined to include groups having 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 carbons in a linear or branched arrangement. For example, "C₁-C₁₀ alkyl" specifically includes methyl, ethyl, *n*-propyl, *i*-propyl, *n*-butyl, *t*-butyl, *i*-butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, and so on. The term "cycloalkyl" means a monocyclic saturated aliphatic hydrocarbon group having the specified number of carbon atoms. For example, "cycloalkyl" includes cyclopropyl, methyl-cyclopropyl, 2,2-dimethyl-cyclobutyl, 2-ethyl-cyclopentyl, cyclohexyl, and so on.

When used in the phrases "C₁-C₆ aralkyl" and "C₁-C₆ heteroaralkyl" the term "C₁-C₆" refers to the alkyl portion of the moiety and does not describe the number of atoms in the aryl and heteroaryl portion of the moiety.

"Alkoxy" represents either a cyclic or non-cyclic alkyl group of indicated number of carbon atoms attached through an oxygen bridge. "Alkoxy" therefore encompasses the definitions of alkyl and cycloalkyl above.

If no number of carbon atoms is specified, the term "alkenyl" refers to a non-aromatic hydrocarbon radical, straight, branched or cyclic, containing from 2 to 10 carbon atoms and at least one carbon to carbon double bond. Preferably one carbon to carbon double bond is present, and up to four non-aromatic carbon-carbon double bonds may be present. Thus, "C₂-C₆ alkenyl" means an alkenyl radical having from 2 to 6 carbon atoms. Alkenyl groups include ethenyl, propenyl, butenyl, 2-methylbutenyl and cyclohexenyl. The straight, branched or cyclic portion of the

alkenyl group may contain double bonds and may be substituted if a substituted alkenyl group is indicated.

The term "alkynyl" refers to a hydrocarbon radical straight, branched or cyclic, containing from 2 to 10 carbon atoms and at least one carbon to carbon triple bond. Up to three carbon-carbon triple bonds may be present. Thus, "C₂-C₆ alkynyl" means an alkynyl radical having from 2 to 6 carbon atoms. Alkynyl groups include ethynyl, propynyl, butynyl, 3-methylbutynyl and so on. The straight, branched or cyclic portion of the alkynyl group may contain triple bonds and may be substituted if a substituted alkynyl group is indicated.

In certain instances, substituents may be defined with a range of carbons that includes zero, such as (C₀-C₆)alkylene-aryl. If aryl is taken to be phenyl, this definition would include phenyl itself as well as -CH₂Ph, -CH₂CH₂Ph, CH(CH₃)CH₂CH(CH₃)Ph, and so on.

As used herein, "aryl" is intended to mean any stable monocyclic or bicyclic carbon ring of up to 7 atoms in each ring, wherein at least one ring is aromatic. Examples of such aryl elements include phenyl, naphthyl, tetrahydronaphthyl, indanyl and biphenyl. In cases where the aryl substituent is bicyclic and one ring is non-aromatic, it is understood that attachment is via the aromatic ring.

The term heteroaryl, as used herein, represents a stable monocyclic or bicyclic ring of up to 7 atoms in each ring, wherein at least one ring is aromatic and contains from 1 to 4 heteroatoms selected from the group consisting of O, N and S. Heteroaryl groups within the scope of this definition include but are not limited to: acridinyl, carbazolyl, cinnolinyl, quinoxalinyl, pyrazolyl, indolyl, benzotriazolyl, furanyl, thienyl, benzothienyl, benzofuranyl, quinolinyl, isoquinolinyl, oxazolyl, isoxazolyl, indolyl, pyrazinyl, pyridazinyl, pyridinyl, pyrimidinyl, pyrrolyl, tetrahydroquinoline. As with the definition of heterocycle below, "heteroaryl" is also understood to include the N-oxide derivative of any nitrogen-containing heteroaryl. In cases where the heteroaryl substituent is bicyclic and one ring is non-aromatic or contains no heteroatoms, it is understood that attachment is via the aromatic ring or via the heteroatom containing ring, respectively.

The term "heterocycle" or "heterocyclyl" as used herein is intended to mean a 5- to 10-membered aromatic or nonaromatic heterocycle containing from 1 to 4 heteroatoms selected from the group consisting of O, N and S, and includes bicyclic groups. "Heterocyclyl" therefore includes the above mentioned heteroaryls,

as well as dihydro and tetrathydro analogs thereof. Further examples of "heterocyclyl" include, but are not limited to the following: benzoimidazolyl, benzofuranyl, benzofurazanyl, benzopyrazolyl, benzotriazolyl, benzothiophenyl, benzoxazolyl, carbazolyl, carbolinyl, cinnolinyl, furanyl, imidazolyl, indolinyl, indolyl, indolaziny, indazolyl, isobenzofuranyl, isoindolyl, isoquinolyl, isothiazolyl, isoxazolyl, naphthpyridinyl, oxadiazolyl, oxazolyl, oxazoline, isoxazoline, oxetanyl, pyranyl, pyrazinyl, pyrazolyl, pyridazinyl, pyridopyridinyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, quinazolinyl, quinolyl, quinoxalinyl, tetrahydropyranyl, tetrazolyl, tetrazolopyridyl, thiadiazolyl, thiazolyl, thienyl, triazolyl, azetidyl, 1,4-dioxanyl, hexahydroazepinyl, piperazinyl, piperidinyl, pyridin-2-onyl, pyrrolidinyl, morpholinyl, thiomorpholinyl, dihydrobenzoimidazolyl, dihydrobenzofuranyl, dihydrobenzothiophenyl, dihydrobenzoxazolyl, dihydrofuranyl, dihydroimidazolyl, dihydroindolyl, dihydroisooxazolyl, dihydroisothiazolyl, dihydrooxadiazolyl, dihydrooxazolyl, dihydropyrazinyl, dihydropyrazolyl, dihydropyridinyl, dihydropyrimidinyl, dihydropyrrolyl, dihydroquinolinyl, dihydrotetrazolyl, dihydrothiadiazolyl, dihydrothiazolyl, dihydrothienyl, dihydrotriazolyl, dihydroazetidyl, methylenedioxybenzoyl, tetrahydrofuranyl, and tetrahydrothienyl, and N-oxides thereof. Attachment of a heterocyclyl substituent can occur via a carbon atom or via a heteroatom.

Preferably, heterocycle is selected from 2-azepinone, benzimidazolyl, 2-diazapinone, imidazolyl, 2-imidazolidinone, indolyl, isoquinolinyl, morpholinyl, piperidyl, piperazinyl, pyridyl, pyrrolidinyl, 2-piperidinone, 2-pyrimidinone, 2-pyrrolidinone, quinolinyl, tetrahydrofuryl, tetrahydroisoquinolinyl, and thienyl.

As appreciated by those of skill in the art, "halo" or "halogen" as used herein is intended to include chloro, fluoro, bromo and iodo.

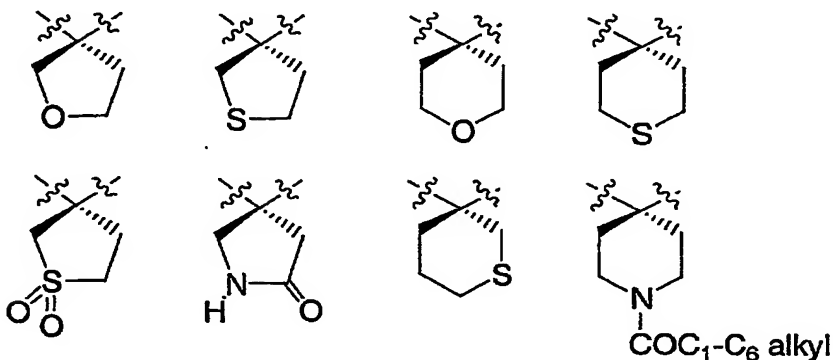
The alkyl, alkenyl, alkynyl, cycloalkyl, aryl, heteroaryl and heterocyclyl substituents may be substituted or unsubstituted, unless specifically defined otherwise. For example, a (C₁-C₆)alkyl may be substituted with one, two or three substituents selected from OH, oxo, halogen, alkoxy, dialkylamino, or heterocyclyl, such as morpholinyl, piperidinyl, and so on. In this case, if one substituent is oxo and the other is OH, the following are included in the definition: -C(=O)CH₂CH(OH)CH₃, -(C=O)OH, -CH₂(OH)CH₂CH(O), and so on.

The moiety formed when, in the definition of R³ and R⁴ and R⁵ and R⁶ on the same carbon atom are combined to form -(CH₂)_u- is illustrated by the following:

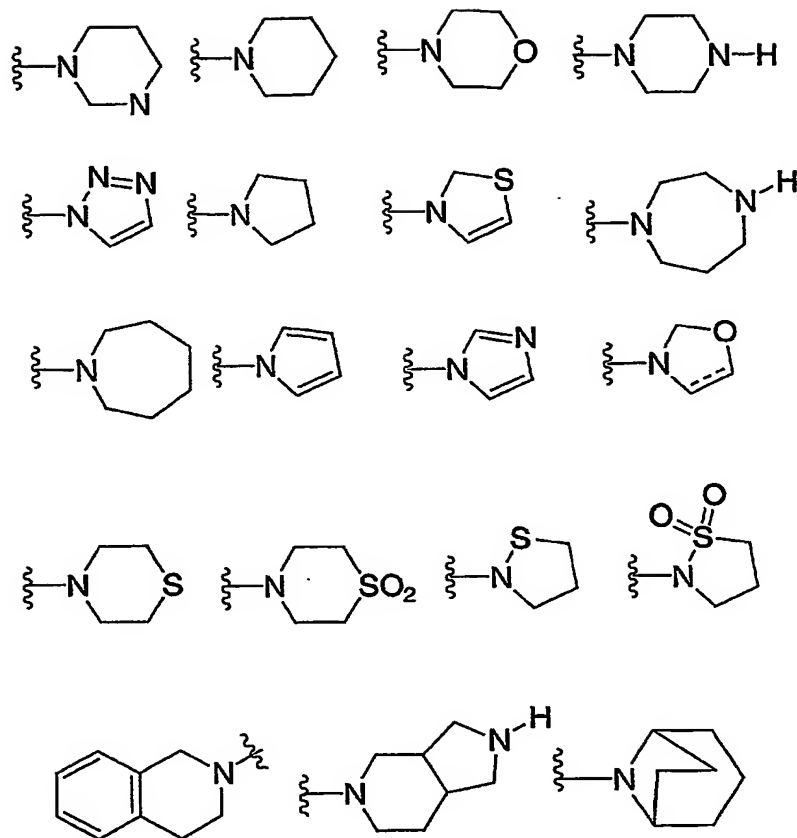


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In addition, such cyclic moieties may optionally include a heteroatom(s). Examples of such heteroatom-containing cyclic moieties include, but are not limited to:



- 10 In certain instances, R⁹ and R¹⁰ are defined such that they can be taken together with the nitrogen to which they are attached to form a monocyclic or bicyclic heterocycle with 5-7 members in each ring and optionally containing, in addition to the nitrogen, one or two additional heteroatoms selected from N, O and S, said heterocycle optionally substituted with one or more substituents selected from
- 15 R⁸. Examples of the heterocycles that can thus be formed include, but are not limited to the following, keeping in mind that the heterocycle is optionally substituted with one or more (and preferably one, two or three) substituents chosen from R⁸:



Preferably R^1 is selected from: $(C=O)C_1-C_6$ alkyl, $(C=O)$ aryl, SO_2C_1-
 5 C_6 alkyl, $(C=O)OC_1-C_6$ alkyl, $(C=O)NR^7R^8$ and SO_2 aryl, optionally substituted with
 one to three substituents selected from R^7 . More preferably, R^1 is acetyl, thioacetyl,
 sulfonamido, N,N -dialkylamido or methylsulfonyl.

Preferably R^2 is selected from aryl, optionally substituted with one to
 three substituents selected from R^7 . More preferably, R^2 is phenyl, optionally
 10 substituted with one to three substituents selected from halo.

Also preferred is the definition of R^3 and R^4 as H.

Preferably R^5 and R^6 are selected from H, C_1-C_6 alkyl, aryl and
 heteroaryl, optionally substituted with one to two substituents selected from R^7 .
 More preferably, one of R^5 and R^6 is phenyl, optionally substituted with one
 15 substituents selected from R^7 , and the other of R^5 and R^6 is H or C_1-C_6 alkyl. Still
 more preferably, one of R^5 and R^6 is phenyl, optionally 3-substituted with one

substituents selected from OH and NH₂, and the other of R⁵ and R⁶ is H or C₁-C₆ alkyl.

Included in the instant invention is the free form of compounds of Formula I, as well as the pharmaceutically acceptable salts and stereoisomers thereof.

5 Some of the specific compounds exemplified herein are the protonated salts of amine compounds. The term "free form" refers to the amine compounds in non-salt form. The encompassed pharmaceutically acceptable salts not only include the salts exemplified for the specific compounds described herein, but also all the typical pharmaceutically acceptable salts of the free form of compounds of Formula I. The

10 free form of the specific salt compounds described may be isolated using techniques known in the art. For example, the free form may be regenerated by treating the salt with a suitable dilute aqueous base solution such as dilute aqueous NaOH, potassium carbonate, ammonia and sodium bicarbonate. The free forms may differ from their respective salt forms somewhat in certain physical properties, such as solubility in

15 polar solvents, but the acid and base salts are otherwise pharmaceutically equivalent to their respective free forms for purposes of the invention.

The pharmaceutically acceptable salts of the instant compounds can be synthesized from the compounds of this invention which contain a basic or acidic moiety by conventional chemical methods. Generally, the salts of the basic

20 compounds are prepared either by ion exchange chromatography or by reacting the free base with stoichiometric amounts or with an excess of the desired salt-forming inorganic or organic acid in a suitable solvent or various combinations of solvents. Similarly, the salts of the acidic compounds are formed by reactions with the appropriate inorganic or organic base.

25 Thus, pharmaceutically acceptable salts of the compounds of this invention include the conventional non-toxic salts of the compounds of this invention as formed by reacting a basic instant compound with an inorganic or organic acid. For example, conventional non-toxic salts include those derived from inorganic acids such as hydrochloric, hydrobromic, sulfuric, sulfamic, phosphoric, nitric

30 and the like, as well as salts prepared from organic acids such as acetic, propionic, succinic, glycolic, stearic, lactic, malic, tartaric, citric, ascorbic, pantoic, maleic, hydroxymaleic, phenylacetic, glutamic, benzoic, salicylic, sulfanilic, 2-acetoxybenzoic, fumaric, toluenesulfonic, methanesulfonic, ethane disulfonic, oxalic, isethionic, trifluoroacetic and the like.

When the compound of the present invention is acidic, suitable "pharmaceutically acceptable salts" refers to salts prepared from pharmaceutically acceptable non-toxic bases including inorganic bases and organic bases. Salts derived from inorganic bases include aluminum, ammonium, calcium, copper, ferric, ferrous, lithium, magnesium, manganic salts, manganous, potassium, sodium, zinc and the like. Particularly preferred are the ammonium, calcium, magnesium, potassium and sodium salts. Salts derived from pharmaceutically acceptable organic non-toxic bases include salts of primary, secondary and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as arginine, betaine caffeine, choline, N,N¹-dibenzylethylenediamine, diethylamin, 2-diethylaminoethanol, 2-dimethylaminoethanol, ethanolamine, ethylenediamine, N-ethylmorpholine, N-ethylpiperidine, glucamine, glucosamine, histidine, hydrabamine, isopropylamine, lysine, methylglucamine, morpholine, piperazine, piperidine, polyamine resins, procaine, purines, theobromine, triethylamine, trimethylamine tripropylamine, tromethamine and the like.

The preparation of the pharmaceutically acceptable salts described above and other typical pharmaceutically acceptable salts is more fully described by Berg *et al.*, "Pharmaceutical Salts," *J. Pharm. Sci.*, 1977:66:1-19.

It will also be noted that the compounds of the present invention are potentially internal salts or zwitterions, since under physiological conditions a deprotonated acidic moiety in the compound, such as a carboxyl group, may be anionic, and this electronic charge might then be balanced off internally against the cationic charge of a protonated or alkylated basic moiety, such as a quaternary nitrogen atom.

The compounds of this invention may be prepared by employing reactions as shown in the following schemes, in addition to other standard manipulations that are known in the literature or exemplified in the experimental procedures. The illustrative schemes below, therefore, are not limited by the compounds listed or by any particular substituents employed for illustrative purposes. Substituent numbering as shown in the schemes does not necessarily correlate to that used in the claims and often, for clarity, a single substituent is shown attached to the compound where multiple substituents are allowed under the definitions of Formula I hereinabove.

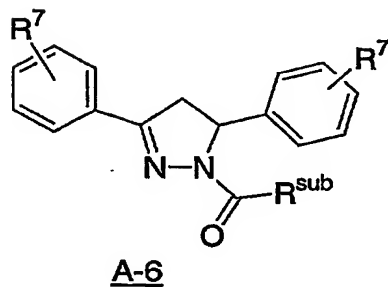
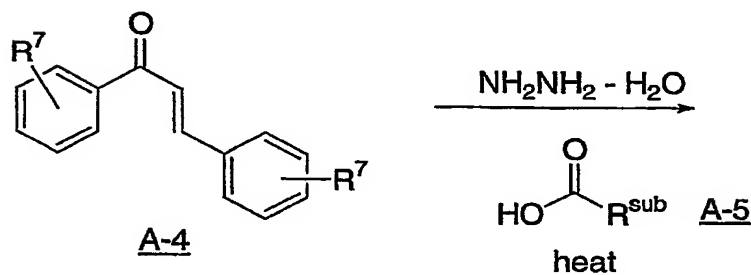
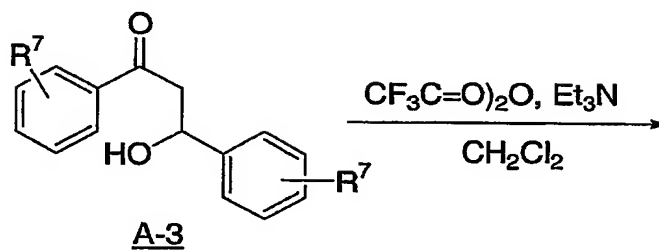
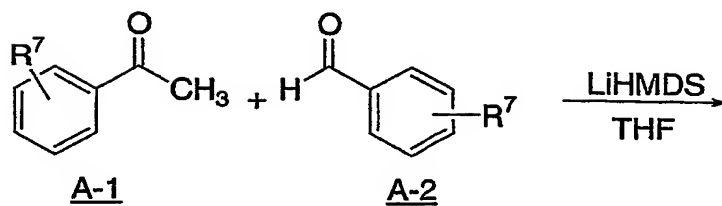
SCHEMES

As shown in Scheme A, condensation of a suitably substituted acetophenone A-1 with a suitably substituted benzaldehyde A-2 provides the β -hydroxylcarbonyl intermediate A-3. Dehydration of A-3 with trifluoroacetic anhydride provides the α,β -unsaturated carbonyl compound A-4. Intermediate A-4 can then undergo reaction with hydrazine in the presence of a carboxylic acid A-5 to provide the N-acyldihydropyrazole A-6.

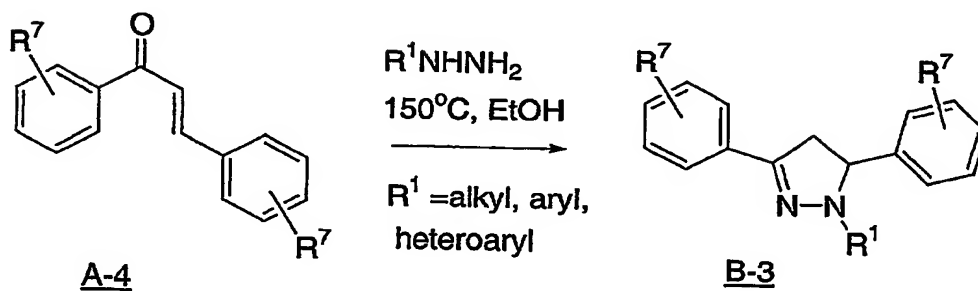
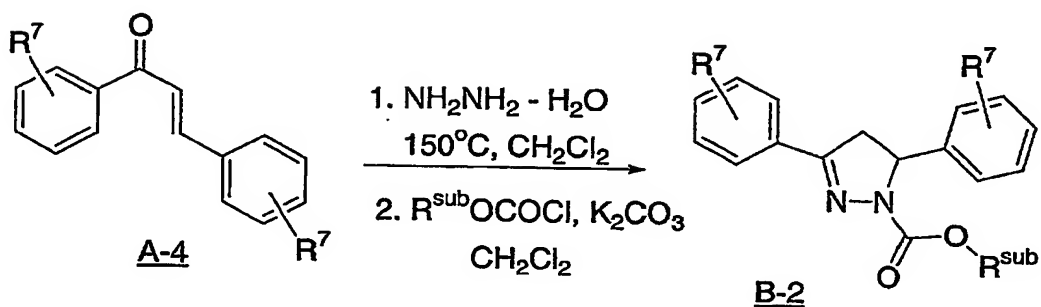
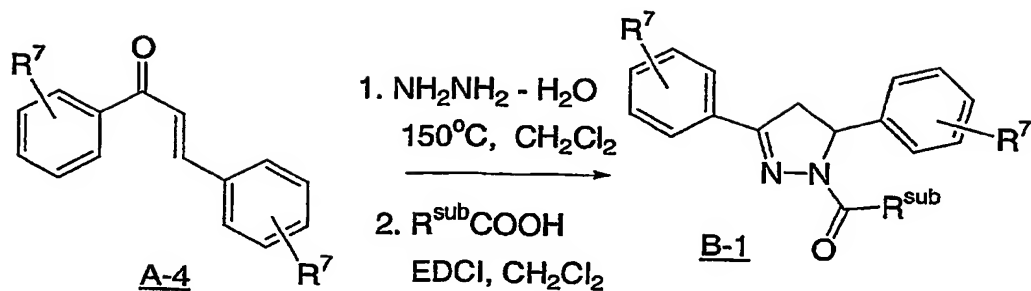
As shown in Scheme B, reaction of the intermediate A-4 with hydrazine may be performed without the carboxylic acid and the intermediate can then be reacted with a variety of acetylating and electrophilic reagents. Scheme B also illustrates the preparation of the instant compounds by reaction of the A-4 intermediate with an N-substituted hydrazine to provide the instant compound B-3.

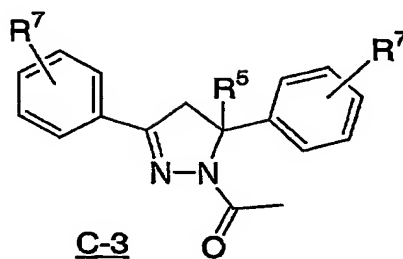
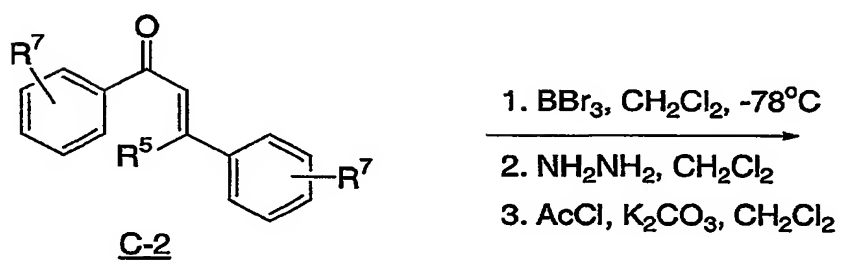
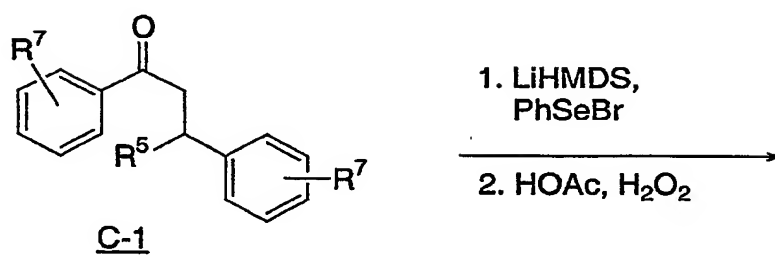
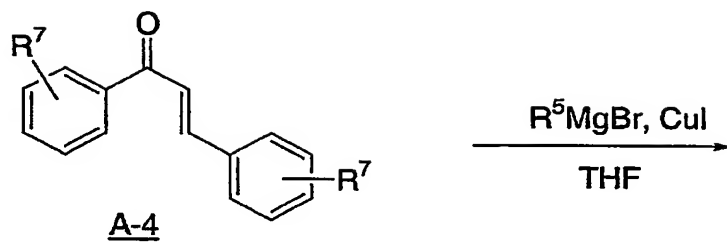
Scheme C illustrates preparation of the 5,5-disubstituted compound of the instant invention. As shown, reaction of the intermediate A-4 with, for example, a Cuprate reagent provides intermediate C1, which can then be dehydrated to provide the substituted chalcone C-2. Subsequent reaction with a hydrazine, as shown, provides the compound of the instant invention.

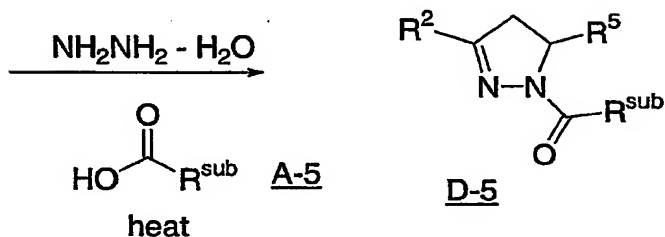
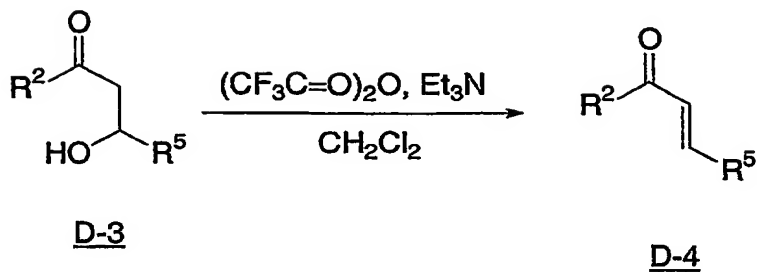
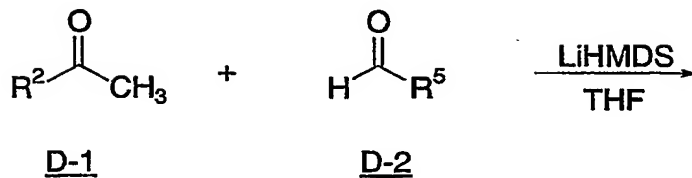
As shown in Scheme D, the reaction sequence shown in scheme A is generally applicable to preparing other compounds of the instant invention that have R^2 and R^5/R^6 other than phenyl.

SCHEME A

SCHEME B



SCHEME C

SCHEME D

5

Utilities

The compounds of the invention find use in a variety of applications. As will be appreciated by those in the art, mitosis may be altered in a variety of ways; that is, one can affect mitosis either by increasing or decreasing the activity of a component in the mitotic pathway. Stated differently, mitosis may be affected (e.g., disrupted) by disturbing equilibrium, either by inhibiting or activating certain components. Similar approaches may be used to alter meiosis.

In a preferred embodiment, the compounds of the invention are used

to modulate mitotic spindle formation, thus causing prolonged cell cycle arrest in mitosis. By "modulate" herein is meant altering mitotic spindle formation, including increasing and decreasing spindle formation. By "mitotic spindle formation" herein is meant organization of microtubules into bipolar structures by mitotic kinesins. By
5 "mitotic spindle dysfunction" herein is meant mitotic arrest and monopolar spindle formation.

The compounds of the invention are useful to bind to and/or modulate the activity of a mitotic kinesin. In a preferred embodiment, the mitotic kinesin is a member of the bimC subfamily of mitotic kinesins (as described in U.S. Patent No.
10 6,284,480, column 5). In a further preferred embodiment, the mitotic kinesin is human KSP, although the activity of mitotic kinesins from other organisms may also be modulated by the compounds of the present invention. In this context, modulate means either increasing or decreasing spindle pole separation, causing malformation, i.e., splaying, of mitotic spindle poles, or otherwise causing morphological
15 perturbation of the mitotic spindle. Also included within the definition of KSP for these purposes are variants and/or fragments of KSP. See PCT Publ. WO 01/31335: "Methods of Screening for Modulators of Cell Proliferation and Methods of Diagnosing Cell Proliferation States", filed Oct. 27, 1999, hereby incorporated by reference in its entirety. In addition, other mitotic kinesins may be inhibited by the
20 compounds of the present invention.

The compounds of the invention are used to treat cellular proliferation diseases. Disease states which can be treated by the methods and compositions provided herein include, but are not limited to, cancer (further discussed below),
25 autoimmune disease, arthritis, graft rejection, inflammatory bowel disease, proliferation induced after medical procedures, including, but not limited to, surgery, angioplasty, and the like. It is appreciated that in some cases the cells may not be in a hyper- or hypoproliferation state (abnormal state) and still require treatment. For example, during wound healing, the cells may be proliferating "normally", but
30 proliferation enhancement may be desired. Similarly, as discussed above, in the agriculture arena, cells may be in a "normal" state, but proliferation modulation may be desired to enhance a crop by directly enhancing growth of a crop, or by inhibiting the growth of a plant or organism which adversely affects the crop. Thus,

in one embodiment, the invention herein includes application to cells or individuals afflicted or impending affliction with any one of these disorders or states.

The compounds, compositions and methods provided herein are particularly deemed useful for the treatment of cancer including solid tumors such as skin, breast, brain, cervical carcinomas, testicular carcinomas, etc. More particularly, cancers that may be treated by the compounds, compositions and methods of the invention include, but are not limited to: Cardiac: sarcoma (angiosarcoma, fibrosarcoma, rhabdomyosarcoma, liposarcoma), myxoma, rhabdomyoma, fibroma, lipoma and teratoma; Lung: bronchogenic carcinoma (squamous cell, undifferentiated small cell, undifferentiated large cell, adenocarcinoma), alveolar (bronchiolar) carcinoma, bronchial adenoma, sarcoma, lymphoma, chondromatous hamartoma, mesothelioma; Gastrointestinal: esophagus (squamous cell carcinoma, adenocarcinoma, leiomyosarcoma, lymphoma), stomach (carcinoma, lymphoma, leiomyosarcoma), pancreas (ductal adenocarcinoma, insulinoma, glucagonoma, gastrinoma, carcinoid tumors, vipoma), small bowel (adenocarcinoma, lymphoma, carcinoid tumors, Kaposi's sarcoma, leiomyoma, hemangioma, lipoma, neurofibroma, fibroma), large bowel (adenocarcinoma, tubular adenoma, villous adenoma, hamartoma, leiomyoma); Genitourinary tract: kidney (adenocarcinoma, Wilm's tumor [nephroblastoma], lymphoma, leukemia), bladder and urethra (squamous cell carcinoma, transitional cell carcinoma, adenocarcinoma), prostate (adenocarcinoma, sarcoma), testis (seminoma, teratoma, embryonal carcinoma, teratocarcinoma, choriocarcinoma, sarcoma, interstitial cell carcinoma, fibroma, fibroadenoma, adenomatoid tumors, lipoma); Liver: hepatoma (hepatocellular carcinoma), cholangiocarcinoma, hepatoblastoma, angiosarcoma, hepatocellular adenoma, hemangioma; Bone: osteogenic sarcoma (osteosarcoma), fibrosarcoma, malignant fibrous histiocytoma, chondrosarcoma, Ewing's sarcoma, malignant lymphoma (reticulum cell sarcoma), multiple myeloma, malignant giant cell tumor chordoma, osteochondroma (osteochondrogenous exostoses), benign chondroma, chondroblastoma, chondromyxofibroma, osteoid osteoma and giant cell tumors; Nervous system: skull (osteoma, hemangioma, granuloma, xanthoma, osteitis deformans), meninges (meningioma, meningiosarcoma, gliomatosis), brain (astrocytoma, medulloblastoma, glioma, ependymoma, germinoma [pinealoma], glioblastoma multiform, oligodendroglioma, schwannoma, retinoblastoma, congenital tumors), spinal cord neurofibroma, meningioma, glioma, sarcoma); Gynecological:

uterus (endometrial carcinoma), cervix (cervical carcinoma, pre-tumor cervical dysplasia), ovaries (ovarian carcinoma [serous cystadenocarcinoma, mucinous cystadenocarcinoma, unclassified carcinoma], granulosa-thecal cell tumors, Sertoli-Leydig cell tumors, dysgerminoma, malignant teratoma), vulva (squamous cell carcinoma, intraepithelial carcinoma, adenocarcinoma, fibrosarcoma, melanoma), vagina (clear cell carcinoma, squamous cell carcinoma, botryoid sarcoma (embryonal rhabdomyosarcoma), fallopian tubes (carcinoma); Hematologic: blood (myeloid leukemia [acute and chronic], acute lymphoblastic leukemia, chronic lymphocytic leukemia, myeloproliferative diseases, multiple myeloma, myelodysplastic syndrome), Hodgkin's disease, non-Hodgkin's lymphoma [malignant lymphoma]; Skin: malignant melanoma, basal cell carcinoma, squamous cell carcinoma, Kaposi's sarcoma, moles dysplastic nevi, lipoma, angioma, dermatofibroma, keloids, psoriasis; and Adrenal glands: neuroblastoma. Thus, the term "cancerous cell" as provided herein, includes a cell afflicted by any one of the above-identified conditions.

The compounds of the instant invention may also be useful as antifungal agents, by modulating the activity of the fungal members of the bimC kinesin subgroup, as is described in U.S. Patent No. 6,284,480.

The compounds of this invention may be administered to mammals, preferably humans, either alone or, preferably, in combination with pharmaceutically acceptable carriers, excipients or diluents, in a pharmaceutical composition, according to standard pharmaceutical practice. The compounds can be administered orally or parenterally, including the intravenous, intramuscular, intraperitoneal, subcutaneous, rectal and topical routes of administration.

Additionally, the compounds of the instant invention may be administered to a mammal in need thereof using a gel extrusion mechanism (GEM) device, such as that described in USSN 60/144,643, filed on July 20, 1999, which is hereby incorporated by reference.

As used herein, the term "composition" is intended to encompass a product comprising the specified ingredients in the specific amounts, as well as any product which results, directly or indirectly, from combination of the specific ingredients in the specified amounts.

The pharmaceutical compositions containing the active ingredient may be in a form suitable for oral use, for example, as tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsions, hard or soft capsules,

or syrups or elixirs. Compositions intended for oral use may be prepared according to any method known to the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents selected from the group consisting of sweetening agents, flavoring agents, coloring agents and preserving agents in order to provide pharmaceutically elegant and palatable preparations. Tablets contain the active ingredient in admixture with non-toxic pharmaceutically acceptable excipients which are suitable for the manufacture of tablets. These excipients may be for example, inert diluents, such as calcium carbonate, sodium carbonate, lactose, calcium phosphate or sodium phosphate; granulating and disintegrating agents, for example, microcrystalline cellulose, sodium crosscarmellose, corn starch, or alginic acid; binding agents, for example starch, gelatin, polyvinyl-pyrrolidone or acacia, and lubricating agents, for example, magnesium stearate, stearic acid or talc. The tablets may be uncoated or they may be coated by known techniques to mask the unpleasant taste of the drug or delay disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a water soluble taste masking material such as hydroxypropyl-methylcellulose or hydroxypropyl-cellulose, or a time delay material such as ethyl cellulose, cellulose acetate butyrate may be employed.

Formulations for oral use may also be presented as hard gelatin capsules wherein the active ingredient is mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate or kaolin, or as soft gelatin capsules wherein the active ingredient is mixed with water soluble carrier such as polyethyleneglycol or an oil medium, for example peanut oil, liquid paraffin, or olive oil.

Aqueous suspensions contain the active material in admixture with excipients suitable for the manufacture of aqueous suspensions. Such excipients are suspending agents, for example sodium carboxymethylcellulose, methylcellulose, hydroxypropylmethyl-cellulose, sodium alginate, polyvinyl-pyrrolidone, gum tragacanth and gum acacia; dispersing or wetting agents may be a naturally-occurring phosphatide, for example lecithin, or condensation products of an alkylene oxide with fatty acids, for example polyoxyethylene stearate, or condensation products of ethylene oxide with long chain aliphatic alcohols, for example heptadecaethylene-oxyctanol, or condensation products of ethylene oxide with partial esters derived from fatty acids and a hexitol such as polyoxyethylene sorbitol monooleate, or condensation products of ethylene oxide with partial esters derived from fatty

acids and hexitol anhydrides, for example polyethylene sorbitan monooleate. The aqueous suspensions may also contain one or more preservatives, for example ethyl, or n-propyl p-hydroxybenzoate, one or more coloring agents, one or more flavoring agents, and one or more sweetening agents, such as sucrose, saccharin or aspartame.

Oily suspensions may be formulated by suspending the active ingredient in a vegetable oil, for example arachis oil, olive oil, sesame oil or coconut oil, or in mineral oil such as liquid paraffin. The oily suspensions may contain a thickening agent, for example beeswax, hard paraffin or cetyl alcohol. Sweetening agents such as those set forth above, and flavoring agents may be added to provide a palatable oral preparation. These compositions may be preserved by the addition of an anti-oxidant such as butylated hydroxyanisol or alpha-tocopherol.

Dispersible powders and granules suitable for preparation of an aqueous suspension by the addition of water provide the active ingredient in admixture with a dispersing or wetting agent, suspending agent and one or more preservatives. Suitable dispersing or wetting agents and suspending agents are exemplified by those already mentioned above. Additional excipients, for example sweetening, flavoring and coloring agents, may also be present. These compositions may be preserved by the addition of an anti-oxidant such as ascorbic acid.

The pharmaceutical compositions of the invention may also be in the form of an oil-in-water emulsions. The oily phase may be a vegetable oil, for example olive oil or arachis oil, or a mineral oil, for example liquid paraffin or mixtures of these. Suitable emulsifying agents may be naturally-occurring phosphatides, for example soy bean lecithin, and esters or partial esters derived from fatty acids and hexitol anhydrides, for example sorbitan monooleate, and condensation products of the said partial esters with ethylene oxide, for example polyoxyethylene sorbitan monooleate. The emulsions may also contain sweetening, flavoring agents, preservatives and antioxidants.

Syrups and elixirs may be formulated with sweetening agents, for example glycerol, propylene glycol, sorbitol or sucrose. Such formulations may also contain a demulcent, a preservative, flavoring and coloring agents and antioxidant.

The pharmaceutical compositions may be in the form of a sterile injectable aqueous solutions. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution and isotonic sodium chloride solution.

The sterile injectable preparation may also be a sterile injectable oil-in-water microemulsion where the active ingredient is dissolved in the oily phase. For example, the active ingredient may be first dissolved in a mixture of soybean oil and lecithin. The oil solution then introduced into a water and glycerol mixture and
5 processed to form a microemulation.

The injectable solutions or microemulsions may be introduced into a patient's blood-stream by local bolus injection. Alternatively, it may be advantageous to administer the solution or microemulsion in such a way as to maintain a constant circulating concentration of the instant compound. In order to maintain such a
10 constant concentration, a continuous intravenous delivery device may be utilized. An example of such a device is the Deltec CADD-PLUS™ model 5400 intravenous pump.

The pharmaceutical compositions may be in the form of a sterile injectable aqueous or oleagenous suspension for intramuscular and subcutaneous
15 administration. This suspension may be formulated according to the known art using those suitable dispersing or wetting agents and suspending agents which have been mentioned above. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally-acceptable diluent or solvent, for example as a solution in 1,3-butane diol. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland
20 fixed oil may be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables.

Compounds of Formula I may also be administered in the form of suppositories for rectal administration of the drug. These compositions can be
25 prepared by mixing the drug with a suitable non-irritating excipient which is solid at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum to release the drug. Such materials include cocoa butter, glycerinated gelatin, hydrogenated vegetable oils, mixtures of polyethylene glycols of various molecular weights and fatty acid esters of polyethylene glycol.

30 For topical use, creams, ointments, jellies, solutions or suspensions, etc., containing the compound of Formula I are employed. (For purposes of this application, topical application shall include mouth washes and gargles.)

The compounds for the present invention can be administered in intranasal form via topical use of suitable intranasal vehicles and delivery devices,

or via transdermal routes, using those forms of transdermal skin patches well known to those of ordinary skill in the art. To be administered in the form of a transdermal delivery system, the dosage administration will, of course, be continuous rather than intermittent throughout the dosage regimen. Compounds of the present invention
5 may also be delivered as a suppository employing bases such as cocoa butter, glycerinated gelatin, hydrogenated vegetable oils, mixtures of polyethylene glycols of various molecular weights and fatty acid esters of polyethylene glycol.

When a compound according to this invention is administered into a human subject, the daily dosage will normally be determined by the prescribing
10 physician with the dosage generally varying according to the age, weight, sex and response of the individual patient, as well as the severity of the patient's symptoms.

In one exemplary application, a suitable amount of compound is administered to a mammal undergoing treatment for cancer. Administration occurs in an amount between about 0.1 mg/kg of body weight to about 60 mg/kg of body
15 weight per day, preferably of between 0.5 mg/kg of body weight to about 40 mg/kg of body weight per day.

The instant compounds are also useful in combination with known therapeutic agents and anti-cancer agents. For instance, the instant compounds are also useful in combination with known anti-cancer agents including the following:
20 estrogen receptor modulators, androgen receptor modulators, retinoid receptor modulators, cytotoxic agents, antiproliferative agents, prenyl-protein transferase inhibitors, HMG-CoA reductase inhibitors, HIV protease inhibitors, reverse transcriptase inhibitors, and other angiogenesis inhibitors. The instant compounds are particularly useful when coadministered with radiation therapy.

25 "Estrogen receptor modulators" refers to compounds which interfere or inhibit the binding of estrogen to the receptor, regardless of mechanism. Examples of estrogen receptor modulators include, but are not limited to, tamoxifen, raloxifene, idoxifene, LY353381, LY117081, toremifene, fulvestrant, 4-[7-(2,2-dimethyl-1-oxopropoxy-4-methyl-2-[4-[2-(1-piperidinyloxy)]phenyl]-2H-1-benzopyran-3-yl]-phenyl-2,2-dimethylpropanoate, 4,4'-dihydroxybenzophenone-2,4-dinitrophenyl-
30 hydrazone, and SH646.

"Androgen receptor modulators" refers to compounds which

interfere or inhibit the binding of androgens to the receptor, regardless of mechanism. Examples of androgen receptor modulators include finasteride and other 5 α -reductase inhibitors, nilutamide, flutamide, bicalutamide, liarozole, and abiraterone acetate.

“Retinoid receptor modulators” refers to compounds that interfere or
 5 inhibit the binding of retinoids to the receptor, regardless of mechanism. Examples of such retinoid receptor modulators include bexarotene, tretinoin, 13-cis-retinoic acid, 9-cis-retinoic acid, α -difluoromethylornithine, ILX23-7553, trans-N-(4'-hydroxyphenyl) retinamide, and N-4-carboxyphenyl retinamide.

“Cytotoxic agents” refer to compounds which cause cell death
 10 primarily by interfering directly with the cell's functioning or inhibit or interfere with cell myosis, including alkylating agents, tumor necrosis factors, intercalators, microtubulin inhibitors, and topoisomerase inhibitors.

Examples of cytotoxic agents include, but are not limited to,
 15 tirapazimine, sertenef, cachectin, ifosfamide, tasonermin, lonidamine, carboplatin, altretamine, prednimustine, dibromodulcitol, ranimustine, fotemustine, nedaplatin, oxaliplatin, temozolomide, heptaplatin, estramustine, improsulfan tosilate, trofosfamide, nimustine, dibrospidium chloride, pumitepa, lobaplatin, satraplatin, profiromycin, cisplatin, irofulven, dexifosfamide, cis-aminedichloro(2-methyl-
 20 pyridine)platinum, benzylguanine, glufosfamide, GPX100, (trans, trans, trans)-bis- μ -(hexane-1,6-diamine)- μ -[diamine-platinum(II)]bis[diamine(chloro)platinum (II)]tetrachloride, diarizidinylspermine, arsenic trioxide, 1-(11-dodecylamino-10-hydroxyundecyl)-3,7-dimethylxanthine, zorubicin, idarubicin, daunorubicin, bisantrene, mitoxantrone, pirarubicin, pinafide, valrubicin, amrubicin, antineoplaston, 3'-deamino-3'-morpholino-13-deoxo-10-hydroxycarminomycin,
 25 annamycin, galarubicin, elinafide, MEN10755, and 4-demethoxy-3-deamino-3-aziridinyl-4-methylsulphonyl-daunorubicin (see WO 00/50032).

Examples of microtubulin inhibitors include paclitaxel, vindesine sulfate, 3',4'-didehydro-4'-deoxy-8'-norvincal leukoblastine, docetaxol, rhizoxin, dolastatin, mivobulin isethionate, auristatin, cemadotin, RPR109881, BMS184476,
 30 vinflunine, cryptophycin, 2,3,4,5,6-pentafluoro-N-(3-fluoro-4-methoxyphenyl)benzene sulfonamide, anhydrovinblastine, N,N-dimethyl-L-valyl-L-valyl-N-methyl-L-valyl-L-prolyl-L-proline-t-butylamide, TDX258, and BMS188797.

Some examples of topoisomerase inhibitors are topotecan, hycaptamine, irinotecan, rubitecan, 6-ethoxypropionyl-3',4'-O-exo-benzylidene-

- chartreusin, 9-methoxy-N,N-dimethyl-5-nitropyrzolo[3,4,5-kl]acridine-2-(6H) propanamine, 1-amino-9-ethyl-5-fluoro-2,3-dihydro-9-hydroxy-4-methyl-1H, 12H-benzo[de]pyrano[3',4':b,7]indolizino[1,2b]quinoline-10,13(9H,15H)dione, lurtotecan, 7-[2-(N-isopropylamino)ethyl]-(20S)camptothecin, BNP1350,
- 5 BNPI1100, BN80915, BN80942, etoposide phosphate, teniposide, sobuzoxane, 2'-dimethylamino-2'-deoxy-etoposide, GL331, N-[2-(dimethylamino)ethyl]-9-hydroxy-5,6-dimethyl-6H-pyrido[4,3-b]carbazole-1-carboxamide, asulacrine, (5a, 5aB, 8aa,9b)-9-[2-[N-[2-(dimethylamino)ethyl]-N-methylamino]ethyl]-5-[4-hydroxy-3,5-dimethoxyphenyl]-5,5a,6,8,8a,9-hexahydrofuro(3',4':6,7)naphtho(2,3-d)-1,3-
- 10 dioxol-6-one, 2,3-(methylenedioxy)-5-methyl-7-hydroxy-8-methoxybenzo[c]-phenanthridinium, 6,9-bis[(2-aminoethyl)amino]benzo[g]isoguinoline-5,10-dione, 5-(3-aminopropylamino)-7,10-dihydroxy-2-(2-hydroxyethylaminomethyl)-6H-pyrzolo[4,5,1-de]acridin-6-one, N-[1-[2(diethylamino)ethylamino]-7-methoxy-9-oxo-9H-thioxanthen-4-ylmethyl]formamide, N-(2-(dimethylamino)ethyl)acridine-
- 15 4-carboxamide, 6-[[2-(dimethylamino)ethyl]amino]-3-hydroxy-7H-indeno[2,1-c]quinolin-7-one, and dimesna.

"Antiproliferative agents" includes antisense RNA and DNA oligonucleotides such as G3139, ODN698, RVASKRAS, GEM231, and INX3001, and antimetabolites such as enocitabine, carmofur, tegafur, pentostatin, doxifluridine,

20 trimetrexate, fludarabine, capecitabine, galocitabine, cytarabine ocfosfate, fosteabine sodium hydrate, raltitrexed, paltitrexid, emitefur, tiazofurin, decitabine, nolatrexed, pemetrexed, nelzarabine, 2'-deoxy-2'-methylidenecytidine, 2'-fluoromethylene-2'-deoxycytidine, N-[5-(2,3-dihydro-benzofuryl)sulfonyl]-N'-(3,4-dichlorophenyl)urea, N6-[4-deoxy-4-[N2-[2(E),4(E)-tetradecadienoyl]glycylamino]-L-glycero-

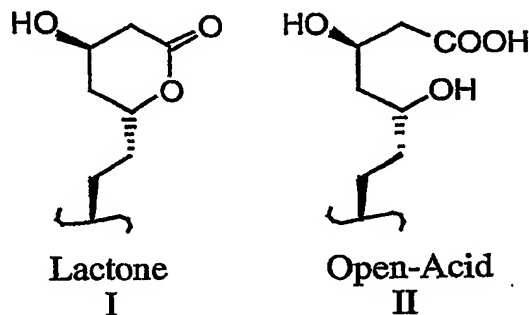
25 B-L-manno-heptopyranosyl]adenine, aplidine, ecteinascidin, troxacitabine, 4-[2-amino-4-oxo-4,6,7,8-tetrahydro-3H-pyrimidino[5,4-b][1,4]thiazin-6-yl-(S)-ethyl]-2,5-thienoyl-L-glutamic acid, aminopterin, 5-fluorouracil, alanosine, 11-acetyl-8-(carbamoyloxymethyl)-4-formyl-6-methoxy-14-oxa-1,11-diazatetracyclo(7.4.1.0.0)-tetradeca-2,4,6-trien-9-yl acetic acid ester, swainsonine, lometrexol, dexrazoxane,

30 methioninase, 2'-cyano-2'-deoxy-N4-palmitoyl-1-B-D-arabino furanosyl cytosine, and 3-aminopyridine-2-carboxaldehyde thiosemicarbazone. "Antiproliferative agents" also includes monoclonal antibodies to growth factors, other than those listed under "angiogenesis inhibitors", such as trastuzumab, and tumor suppressor genes,

such as p53, which can be delivered via recombinant virus-mediated gene transfer (see U.S. Patent No. 6,069,134, for example).

"HMG-CoA reductase inhibitors" refers to inhibitors of 3-hydroxy-3-methylglutaryl-CoA reductase. Compounds which have inhibitory activity for HMG-CoA reductase can be readily identified by using assays well-known in the art. For example, see the assays described or cited in U.S. Patent 4,231,938 at col. 6, and WO 84/02131 at pp. 30-33. The terms "HMG-CoA reductase inhibitor" and "inhibitor of HMG-CoA reductase" have the same meaning when used herein.

Examples of HMG-CoA reductase inhibitors that may be used include but are not limited to lovastatin (MEVACOR®; see U.S. Patent Nos. 4,231,938, 4,294,926 and 4,319,039), simvastatin (ZOCOR®; see U.S. Patent Nos. 4,444,784, 4,820,850 and 4,916,239), pravastatin (PRAVACHOL®; see U.S. Patent Nos. 4,346,227, 4,537,859, 4,410,629, 5,030,447 and 5,180,589), fluvastatin (LESCOL®; see U.S. Patent Nos. 5,354,772, 4,911,165, 4,929,437, 5,189,164, 5,118,853, 5,290,946 and 5,356,896), atorvastatin (LIPITOR®; see U.S. Patent Nos. 5,273,995, 4,681,893, 5,489,691 and 5,342,952) and cerivastatin (also known as rivastatin and BAYCHOL®; see US Patent No. 5,177,080). The structural formulas of these and additional HMG-CoA reductase inhibitors that may be used in the instant methods are described at page 87 of M. Yalpani, "Cholesterol Lowering Drugs", *Chemistry & Industry*, pp. 85-89 (5 February 1996) and US Patent Nos. 4,782,084 and 4,885,314. The term HMG-CoA reductase inhibitor as used herein includes all pharmaceutically acceptable lactone and open-acid forms (i.e., where the lactone ring is opened to form the free acid) as well as salt and ester forms of compounds which have HMG-CoA reductase inhibitory activity, and therefor the use of such salts, esters, open-acid and lactone forms is included within the scope of this invention. An illustration of the lactone portion and its corresponding open-acid form is shown below as structures I and II.



In HMG-CoA reductase inhibitors where an open-acid form can exist, salt and ester forms may preferably be formed from the open-acid, and all such forms are included within the meaning of the term "HMG-CoA reductase inhibitor" as used herein. Preferably, the HMG-CoA reductase inhibitor is selected from lovastatin and simvastatin, and most preferably simvastatin. Herein, the term "pharmaceutically acceptable salts" with respect to the HMG-CoA reductase inhibitor shall mean non-toxic salts of the compounds employed in this invention which are generally prepared by reacting the free acid with a suitable organic or inorganic base, particularly those formed from cations such as sodium, potassium, aluminum, calcium, lithium, magnesium, zinc and tetramethylammonium, as well as those salts formed from amines such as ammonia, ethylenediamine, N-methylglucamine, lysine, arginine, ornithine, choline, N,N'-dibenzylethylenediamine, chloroprocaine, diethanolamine, procaine, N-benzylphenethylamine, 1-p-chlorobenzyl-2-pyrrolidine-1'-yl-methylbenzimidazole, diethylamine, piperazine, and tris(hydroxymethyl) aminomethane. Further examples of salt forms of HMG-CoA reductase inhibitors may include, but are not limited to, acetate, benzenesulfonate, benzoate, bicarbonate, bisulfate, bitartrate, borate, bromide, calcium edetate, camsylate, carbonate, chloride, clavulanate, citrate, dihydrochloride, edetate, edisylate, estolate, esylate, fumarate, gluceptate, gluconate, glutamate, glycolylarsanilate, hexylresorcinate, hydrabamine, hydrobromide, hydrochloride, hydroxynapthoate, iodide, isothionate, lactate, lactobionate, laurate, malate, maleate, mandelate, mesylate, methylsulfate, mucate, napsylate, nitrate, oleate, oxalate, pamaote, palmitate, panthothenate, phosphate/diphosphate, polygalacturonate, salicylate, stearate, subacetate, succinate, tannate, tartrate, teoclate, tosylate, triethiodide, and valerate.

Ester derivatives of the described HMG-CoA reductase inhibitor compounds may act as prodrugs which, when absorbed into the bloodstream of a warm-blooded animal, may cleave in such a manner as to release the drug form and permit the drug to afford improved therapeutic efficacy.

"Prenyl-protein transferase inhibitor" refers to a compound which inhibits any one or any combination of the prenyl-protein transferase enzymes, including farnesyl-protein transferase (FPTase), geranylgeranyl-protein transferase type I (GGPTase-I), and geranylgeranyl-protein transferase type-II (GGPTase-II, also called Rab GGPTase). Examples of prenyl-protein transferase inhibiting compounds include (\pm)-6-[amino(4-chlorophenyl)(1-methyl-1H-imidazol-5-

yl)methyl]-4-(3-chlorophenyl)-1-methyl-2(1*H*)-quinolinone, (-)-6-[amino(4-chlorophenyl)(1-methyl-1*H*-imidazol-5-yl)methyl]-4-(3-chlorophenyl)-1-methyl-2(1*H*)-quinolinone, (+)-6-[amino(4-chlorophenyl)(1-methyl-1*H*-imidazol-5-yl)methyl]-4-(3-chlorophenyl)-1-methyl-2(1*H*)-quinolinone, 5(*S*)-*n*-butyl-1-(2,3-dimethylphenyl)-4-[1-(4-cyanobenzyl)-5-imidazolylmethyl]-2-piperazinone, (*S*)-1-(3-chlorophenyl)-4-[1-(4-cyanobenzyl)-5-imidazolylmethyl]-5-[2-(ethanesulfonyl)methyl]-2-piperazinone, 5(*S*)-*n*-Butyl-1-(2-methylphenyl)-4-[1-(4-cyanobenzyl)-5-imidazolylmethyl]-2-piperazinone, 1-(3-chlorophenyl)-4-[1-(4-cyanobenzyl)-2-methyl-5-imidazolylmethyl]-2-piperazinone, 1-(2,2-diphenylethyl)-3-[*N*-(1-(4-cyanobenzyl)-1*H*-imidazol-5-ylethyl)carbamoyl]piperidine, 4-{5-[4-hydroxymethyl-4-(4-chloropyridin-2-ylmethyl)-piperidine-1-ylmethyl]-2-methylimidazol-1-ylmethyl} benzonitrile, 4-{5-[4-hydroxymethyl-4-(3-chlorobenzyl)-piperidine-1-ylmethyl]-2-methylimidazol-1-ylmethyl} benzonitrile, 4-{3-[4-(2-oxo-2*H*-pyridin-1-yl)benzyl]-3*H*-imidazol-4-ylmethyl} benzonitrile, 4-{3-[4-(5-chloro-2-oxo-2*H*-[1,2']bipyridin-5'-ylmethyl]-3*H*-imidazol-4-ylmethyl} benzonitrile, 4-{3-[4-(2-oxo-2*H*-[1,2'] bipyridin-5'-ylmethyl)-3*H*-imidazol-4-ylmethyl} benzonitrile, 4-[3-(2-oxo-1-phenyl-1,2-dihydropyridin-4-ylmethyl)-3*H*-imidazol-4-ylmethyl} benzonitrile, 18,19-dihydro-19-oxo-5*H*,17*H*-6,10:12,16-dimetheno-1*H*-imidazo[4,3-*c*][1,11,4]dioxazacyclo-nonadecine-9-carbonitrile, (±)-19,20-dihydro-19-oxo-5*H*-18,21-ethano-12,14-etheno-6,10-metheno-22*H*-benzo[*d*]imidazo[4,3-*k*][1,6,9,12]oxatriazacyclooctadecine-9-carbonitrile, 19,20-dihydro-19-oxo-5*H*,17*H*-18,21-ethano-6,10:12,16-dimetheno-22*H*-imidazo[3,4-*h*][1,8,11,14]-oxatriazacycloeicosine-9-carbonitrile, and (±)-19,20-dihydro-3-methyl-19-oxo-5*H*-18,21-ethano-12,14-etheno-6,10-metheno-22*H*-benzo[*d*]imidazo[4,3-*k*][1,6,9,12]oxa-triazacyclooctadecine-9-carbonitrile.

Other examples of prenyl-protein transferase inhibitors can be found in the following publications and patents: WO 96/30343, WO 97/18813, WO 97/21701, WO 97/23478, WO 97/38665, WO 98/28980, WO 98/29119, WO 95/32987, U.S. Patent No. 5,420,245, U.S. Patent No. 5,523,430, U.S. Patent No. 5,532,359, U.S. Patent No. 5,510,510, U.S. Patent No. 5,589,485, U.S. Patent No. 5,602,098, European Patent Publ. 0 618 221, European Patent Publ. 0 675 112, European Patent Publ. 0 604 181, European Patent Publ. 0 696 593, WO 94/19357, WO 95/08542, WO 95/11917, WO 95/12612, WO 95/12572, WO 95/10514, U.S. Patent No. 5,661,152, WO 95/10515, WO 95/10516, WO 95/24612, WO 95/34535,

WO 95/25086, WO 96/05529, WO 96/06138, WO 96/06193, WO 96/16443,
 WO 96/21701, WO 96/21456, WO 96/22278, WO 96/24611, WO 96/24612,
 WO 96/05168, WO 96/05169, WO 96/00736, U.S. Patent No. 5,571,792,
 WO 96/17861, WO 96/33159, WO 96/34850, WO 96/34851, WO 96/30017,
 5 WO 96/30018, WO 96/30362, WO 96/30363, WO 96/31111, WO 96/31477,
 WO 96/31478, WO 96/31501, WO 97/00252, WO 97/03047, WO 97/03050,
 WO 97/04785, WO 97/02920, WO 97/17070, WO 97/23478, WO 97/26246,
 WO 97/30053, WO 97/44350, WO 98/02436, and U.S. Patent No. 5,532,359.

For an example of the role of a prenyl-protein transferase inhibitor on angiogenesis
 10 see European J. of Cancer, Vol. 35, No. 9, pp.1394-1401 (1999).

Examples of HIV protease inhibitors include amprenavir, abacavir,
 CGP-73547, CGP-61755, DMP-450, indinavir, nelfinavir, tipranavir, ritonavir,
 saquinavir, ABT-378, AG 1776, and BMS-232,632. Examples of reverse
 transcriptase inhibitors include delaviridine, efavirenz, GS-840, HB Y097,
 15 lamivudine, nevirapine, AZT, 3TC, ddC, and ddI.

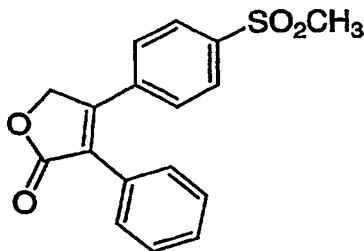
"Angiogenesis inhibitors" refers to compounds that inhibit the
 formation of new blood vessels, regardless of mechanism. Examples of angiogenesis
 inhibitors include, but are not limited to, tyrosine kinase inhibitors, such as inhibitors
 of the tyrosine kinase receptors Flt-1 (VEGFR1) and Flk-1/KDR (VEGFR20),
 20 inhibitors of epidermal-derived, fibroblast-derived, or platelet derived growth factors,
 MMP (matrix metalloprotease) inhibitors, integrin blockers, interferon- α , interleukin-
 12, pentosan polysulfate, cyclooxygenase inhibitors, including nonsteroidal anti-
 inflammatories (NSAIDs) like aspirin and ibuprofen as well as selective cyclooxy-
 genase-2 inhibitors like celecoxib and rofecoxib (PNAS, Vol. 89, p. 7384 (1992);
 25 JNCI, Vol. 69, p. 475 (1982); Arch. Ophthalmol., Vol. 108, p.573 (1990); Anat. Rec.,
 Vol. 238, p. 68 (1994); FEBS Letters, Vol. 372, p. 83 (1995); Clin. Orthop. Vol. 313,
 p. 76 (1995); J. Mol. Endocrinol., Vol. 16, p.107 (1996); Jpn. J. Pharmacol., Vol. 75,
 p. 105 (1997); Cancer Res., Vol. 57, p. 1625 (1997); Cell, Vol. 93, p. 705 (1998);
 Intl. J. Mol. Med., Vol. 2, p. 715 (1998); J. Biol. Chem., Vol. 274, p. 9116 (1999)),
 30 carboxyamidotriazole, combretastatin A-4, squalamine, 6-O-chloroacetyl-carbonyl)-
 fumagillol, thalidomide, angiostatin, troponin-1, angiotensin II antagonists (see
 Fernandez et al., J. Lab. Clin. Med. 105:141-145 (1985)), and antibodies to VEGF
 (see, Nature Biotechnology, Vol. 17, pp.963-968 (October 1999); Kim et al., Nature,
 362, 841-844 (1993); WO 00/44777; and WO 00/61186).

As described above, the combinations with NSAID's are directed to the use of NSAID's which are potent COX-2 inhibiting agents. For purposes of this specification an NSAID is potent if it possess an IC₅₀ for the inhibition of COX-2 of 1 μ M or less as measured by the cell or microsomal assay disclosed herein.

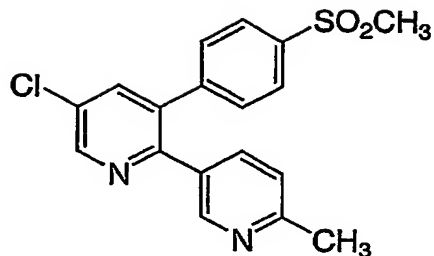
5 The invention also encompasses combinations with NSAID's which are selective COX-2 inhibitors. For purposes of this specification NSAID's which are selective inhibitors of COX-2 are defined as those which possess a specificity for inhibiting COX-2 over COX-1 of at least 100 fold as measured by the ratio of IC₅₀ for COX-2 over IC₅₀ for COX-1 evaluated by the cell or micromsal assay disclosed
 10 hereunder. Such compounds include, but are not limited to those disclosed in U.S. 5,474,995, issued December 12, 1995, U.S. 5,861,419, issued January 19, 1999, U.S. 6,001,843, issued December 14, 1999, U.S. 6,020,343, issued February 1, 2000, U.S. 5,409,944, issued April 25, 1995, U.S. 5,436,265, issued July 25, 1995, U.S. 5,536,752, issued July 16, 1996, U.S. 5,550,142, issued August 27, 1996,
 15 U.S. 5,604,260, issued February 18, 1997, U.S. 5,698,584, issued December 16, 1997, U.S. 5,710,140, issued January 20, 1998, WO 94/15932, published July 21, 1994, U.S. 5,344,991, issued June 6, 1994, U.S. 5,134,142, issued July 28, 1992, U.S. 5,380,738, issued January 10, 1995, U.S. 5,393,790, issued February 20, 1995, U.S. 5,466,823, issued November 14, 1995, U.S. 5,633,272, issued May 27, 1997,
 20 and U.S. 5,932,598, issued August 3, 1999, all of which are hereby incorporated by reference.

Inhibitors of COX-2 that are particularly useful in the instant method of treatment are:

25 3-phenyl-4-(4-(methylsulfonyl)phenyl)-2-(5H)-furanone; and



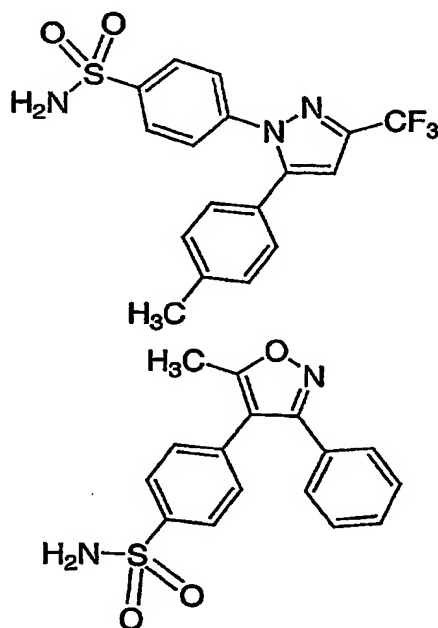
30 5-chloro-3-(4-methylsulfonyl)phenyl-2-(2-methyl-5-pyridinyl)pyridine;

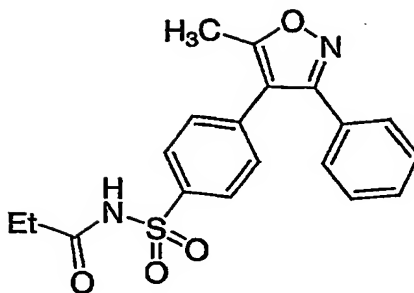


or a pharmaceutically acceptable salt thereof.

General and specific synthetic procedures for the preparation of the
5 COX-2 inhibitor compounds described above are found in U.S. Patent No. 5,474,995,
issued December 12, 1995, U.S. Patent No. 5,861,419, issued January 19, 1999, and
U.S. Patent No. 6,001,843, issued December 14, 1999, all of which are herein
incorporated by reference.

10 Compounds that have been described as specific inhibitors of COX-2
and are therefore useful in the present invention include, but are not limited to, the
following:





or a pharmaceutically acceptable salt thereof.

Compounds that are described as specific inhibitors of COX-2
 5 and are therefore useful in the present invention, and methods of synthesis thereof,
 can be found in the following patents, pending applications and publications, which
 are herein incorporated by reference: WO 94/15932, published July 21, 1994, U.S.
 Patent No. 5,344,991, issued June 6, 1994, U.S. Patent No. 5,134,142, issued July 28,
 1992, U.S. Patent No. 5,380,738, issued January 10, 1995, U.S. Patent No. 5,393,790,
 10 issued February 20, 1995, U.S. Patent No. 5,466,823, issued November 14, 1995,
 U.S. Patent No. 5,633,272, issued May 27, 1997, and U.S. Patent No. 5,932,598,
 issued August 3, 1999.

Compounds which are specific inhibitors of COX-2 and are therefore
 useful in the present invention, and methods of synthesis thereof, can be found
 15 in the following patents, pending applications and publications, which are herein
 incorporated by reference: U.S. Patent No. 5,474,995, issued December 12, 1995,
 U.S. Patent No. 5,861,419, issued January 19, 1999, U.S. Patent No. 6,001,843,
 issued December 14, 1999, U.S. Patent No. 6,020,343, issued February 1, 2000,
 U.S. Patent No. 5,409,944, issued April 25, 1995, U.S. Patent No. 5,436,265, issued
 20 July 25, 1995, U.S. Patent No. 5,536,752, issued July 16, 1996, U.S. Patent No.
 5,550,142, issued August 27, 1996, U.S. Patent No. 5,604,260, issued February 18,
 1997, U.S. Patent No. 5,698,584, issued December 16, 1997, and U.S. Patent No.
 5,710,140, issued January 20, 1998.

Other examples of angiogenesis inhibitors include, but are not limited
 25 to, endostatin, taurine, ranpirinase, IM862, 5-methoxy-4-[2-methyl-3-(3-methyl-2-
 butenyl)oxiranyl]-1-oxaspiro[2,5]oct-6-yl(chloroacetyl)carbamate, acetyldinanaline,
 5-amino-1-[[3,5-dichloro-4-(4-chlorobenzoyl)phenyl]methyl]-1H-1,2,3-triazole-4-

carboxamide, CM101, squalamine, combretastatin, RPI4610, NX31838, sulfated mannopentaose phosphate, 7,7-(carbonyl-bis[imino-N-methyl-4,2-pyrrolocarbonyl-imino[N-methyl-4,2-pyrrole]-carbonylimino]-bis-(1,3-naphthalene disulfonate), and 3-[(2,4-dimethylpyrrol-5-yl)methylene]-2-indolinone (SU5416).

5 As used above, "integrin blockers" refers to compounds which selectively antagonize, inhibit or counteract binding of a physiological ligand to the $\alpha_v\beta_3$ integrin, to compounds which selectively antagonize, inhibit or counteract binding of a physiological ligand to the $\alpha_v\beta_5$ integrin, to compounds which antagonize, inhibit or counteract binding of a physiological ligand to both the $\alpha_v\beta_3$ integrin and the $\alpha_v\beta_5$ integrin, and to compounds which antagonize, inhibit or counteract the activity of the particular integrin(s) expressed on capillary endothelial cells. The term also refers to antagonists of the $\alpha_v\beta_6$, $\alpha_v\beta_8$, $\alpha_1\beta_1$, $\alpha_2\beta_1$, $\alpha_5\beta_1$, $\alpha_6\beta_1$ and $\alpha_6\beta_4$ integrins. The term also refers to antagonists of any combination of $\alpha_v\beta_3$, $\alpha_v\beta_5$, $\alpha_v\beta_6$, $\alpha_v\beta_8$, $\alpha_1\beta_1$, $\alpha_2\beta_1$, $\alpha_5\beta_1$, $\alpha_6\beta_1$ and $\alpha_6\beta_4$ integrins.

15 Some specific examples of tyrosine kinase inhibitors include N-(trifluoromethylphenyl)-5-methylisoxazol-4-carboxamide, 3-[(2,4-dimethylpyrrol-5-yl)methylidenyl]indolin-2-one, 17-(allylamino)-17-demethoxygeldanamycin, 4-(3-chloro-4-fluorophenylamino)-7-methoxy-6-[3-(4-morpholinyl)propoxyl]quinazoline, N-(3-ethynylphenyl)-6,7-bis(2-methoxyethoxy)-4-quinazolinamine, BIBX1382, 20 2,3,9,10,11,12-hexahydro-10-(hydroxymethyl)-10-hydroxy-9-methyl-9,12-epoxy-1H-diindolo[1,2,3-fg:3',2',1'-kl]pyrrolo[3,4-i][1,6]benzodiazocin-1-one, SH268, genistein, STI571, CEP2563, 4-(3-chlorophenylamino)-5,6-dimethyl-7H-pyrrolo[2,3-d]pyrimidinemethane sulfonate, 4-(3-bromo-4-hydroxyphenyl)amino-6,7-dimethoxyquinazoline, 4-(4'-hydroxyphenyl)amino-6,7-dimethoxyquinazoline, 25 SU6668, STI571A, N-4-chlorophenyl-4-(4-pyridylmethyl)-1-phthalazinamine, EMD121974 and imatinib mesylate (GleevecTM).

The instant compounds are also useful, alone or in combination with platelet fibrinogen receptor (GP IIb/IIIa) antagonists, such as tirofiban, to inhibit metastasis of cancerous cells. Tumor cells can activate platelets largely via thrombin 30 generation. This activation is associated with the release of VEGF. The release of VEGF enhances metastasis by increasing extravasation at points of adhesion to vascular endothelium (Amirkhosravi, *Platelets* 10, 285-292, 1999). Therefore, the present compounds can serve to inhibit metastasis, alone or in combination with

GP IIb/IIIa) antagonists. Examples of other fibrinogen receptor antagonists include abciximab, eptifibatide, sibrafiban, lamifiban, lotrafiban, cromofiban, and CT50352.

If formulated as a fixed dose, such combination products employ the compounds of this invention within the dosage range described below and the other
5 pharmaceutically active agent(s) within its approved dosage range. Compounds of the instant invention may alternatively be used sequentially with known pharmaceutically acceptable agent(s) when a combination formulation is inappropriate.

The term "administration" and variants thereof (e.g., "administering" a compound) in reference to a compound of the invention means introducing the
10 compound or a prodrug of the compound into the system of the animal in need of treatment. When a compound of the invention or prodrug thereof is provided in combination with one or more other active agents (e.g., a cytotoxic agent, etc.), "administration" and its variants are each understood to include concurrent and sequential introduction of the compound or prodrug thereof and other agents.

As used herein, the term "composition" is intended to encompass a
15 product comprising the specified ingredients in the specified amounts, as well as any product which results, directly or indirectly, from combination of the specified ingredients in the specified amounts.

The term "therapeutically effective amount" as used herein means
20 that amount of active compound or pharmaceutical agent that elicits the biological or medicinal response in a tissue, system, animal or human that is being sought by a researcher, veterinarian, medical doctor or other clinician.

The term "treating cancer" or "treatment of cancer" refers to
administration to a mammal afflicted with a cancerous condition and refers to an
25 effect that alleviates the cancerous condition by killing the cancerous cells, but also to an effect that results in the inhibition of growth and/or metastasis of the cancer.

The scope of the invention therefore encompasses the use of the
instantly claimed compounds in combination with a second compound selected from:

- 1) an estrogen receptor modulator,
- 30 2) an androgen receptor modulator,
- 3) retinoid receptor modulator,
- 4) a cytotoxic agent,
- 5) an antiproliferative agent,
- 6) a prenyl-protein transferase inhibitor,

- 7) an HMG-CoA reductase inhibitor,
- 8) an HIV protease inhibitor,
- 9) a reverse transcriptase inhibitor, and
- 10) an angiogenesis inhibitor.

5 Preferred angiogenesis inhibitors to be used as the second compound are a tyrosine kinase inhibitor, an inhibitor of epidermal-derived growth factor, an inhibitor of fibroblast-derived growth factor, an inhibitor of platelet derived growth factor, an MMP (matrix metalloprotease) inhibitor, an integrin blocker, interferon- α , interleukin-12, pentosan polysulfate, a cyclooxygenase inhibitor, carboxyamido-
10 triazole, combretastatin A-4, squalamine, 6-O-chloroacetyl-carbonyl)-fumagillol, thalidomide, angiostatin, troponin-1, or an antibody to VEGF. Preferred estrogen receptor modulators are tamoxifen and raloxifene.

Also included in the scope of the claims is a method of treating cancer that comprises administering a therapeutically effective amount of a compound
15 of Formula I in combination with radiation therapy and/or in combination with a compound selected from:

- 1) an estrogen receptor modulator,
- 2) an androgen receptor modulator,
- 3) retinoid receptor modulator,
- 20 4) a cytotoxic agent,
- 5) an antiproliferative agent,
- 6) a prenyl-protein transferase inhibitor,
- 7) an HMG-CoA reductase inhibitor,
- 8) an HIV protease inhibitor,
- 25 9) a reverse transcriptase inhibitor, and
- 10) an angiogenesis inhibitor.

And yet another embodiment of the invention is a method of treating cancer that comprises administering a therapeutically effective amount of a compound of Formula I in combination with paclitaxel or trastuzumab.

30 The invention further encompasses a method of treating or preventing cancer that comprises administering a therapeutically effective amount of a compound of Formula I in combination with a COX-2 inhibitor.

The invention further comprises the use of the instant compounds in a method to screen for other compounds that bind to KSP. To employ the compounds of the invention in a method of screening for compounds that bind to KSP kinesin, the KSP is bound to a support, and a compound of the invention (which is a mitotic agent) is added to the assay. Alternatively, the compound of the invention is bound to the support and KSP is added. Classes of compounds among which novel binding agents may be sought include specific antibodies, non-natural binding agents identified in screens of chemical libraries, peptide analogs, etc. Of particular interest are screening assays for candidate agents that have a low toxicity for human cells.

5 A wide variety of assays may be used for this purpose, including labeled *in vitro* protein-protein binding assays, electrophoretic mobility shift assays, immunoassays for protein binding, functional assays (phosphorylation assays, etc.) and the like.

The determination of the binding of the mitotic agent to KSP may be done in a number of ways. In a preferred embodiment, the mitotic agent (the compound of the invention) is labeled, for example, with a fluorescent or radioactive moiety and binding determined directly. For example, this may be done by attaching all or a portion of KSP to a solid support, adding a labeled mitotic agent (for example a compound of the invention in which at least one atom has been replaced by a detectable isotope), washing off excess reagent, and determining whether the amount of the label is that present on the solid support. Various blocking and washing steps may be utilized as is known in the art.

By "labeled" herein is meant that the compound is either directly or indirectly labeled with a label which provides a detectable signal, e.g., radioisotope, fluorescent tag, enzyme, antibodies, particles such as magnetic particles, chemiluminescent tag, or specific binding molecules, etc. Specific binding molecules include pairs, such as biotin and streptavidin, digoxin and antidigoxin etc. For the specific binding members, the complementary member would normally be labeled with a molecule which provides for detection, in accordance with known procedures, as outlined above. The label can directly or indirectly provide a detectable signal.

30 In some embodiments, only one of the components is labeled. For example, the kinesin proteins may be labeled at tyrosine positions using ^{125}I , or with fluorophores. Alternatively, more than one component may be labeled with different labels; using ^{125}I for the proteins, for example, and a fluorophor for the mitotic agents.

The compounds of the invention may also be used as competitors

to screen for additional drug candidates. "Candidate bioactive agent" or "drug candidate" or grammatical equivalents as used herein describe any molecule, e.g., protein, oligopeptide, small organic molecule, polysaccharide, polynucleotide, etc., to be tested for bioactivity. They may be capable of directly or indirectly altering the cellular proliferation phenotype or the expression of a cellular proliferation sequence, including both nucleic acid sequences and protein sequences. In other cases, alteration of cellular proliferation protein binding and/or activity is screened. Screens of this sort may be performed either in the presence or absence of microtubules. In the case where protein binding or activity is screened, preferred embodiments exclude molecules already known to bind to that particular protein, for example, polymer structures such as microtubules, and energy sources such as ATP. Preferred embodiments of assays herein include candidate agents which do not bind the cellular proliferation protein in its endogenous native state termed herein as "exogenous" agents. In another preferred embodiment, exogenous agents further exclude antibodies to KSP.

Candidate agents can encompass numerous chemical classes, though typically they are organic molecules, preferably small organic compounds having a molecular weight of more than 100 and less than about 2,500 daltons. Candidate agents comprise functional groups necessary for structural interaction with proteins, particularly hydrogen bonding and lipophilic binding, and typically include at least an amine, carbonyl, hydroxyl, ether, or carboxyl group, preferably at least two of the functional chemical groups. The candidate agents often comprise cyclical carbon or heterocyclic structures and/or aromatic or polyaromatic structures substituted with one or more of the above functional groups. Candidate agents are also found among biomolecules including peptides, saccharides, fatty acids, steroids, purines, pyrimidines, derivatives, structural analogs or combinations thereof. Particularly preferred are peptides.

Candidate agents are obtained from a wide variety of sources including libraries of synthetic or natural compounds. For example, numerous means are available for random and directed synthesis of a wide variety of organic compounds and biomolecules, including expression of randomized oligonucleotides. Alternatively, libraries of natural compounds in the form of bacterial, fungal, plant and animal extracts are available or readily produced. Additionally, natural or synthetically produced libraries and compounds are readily modified through conventional

chemical, physical and biochemical means. Known pharmacological agents may be subjected to directed or random chemical modifications, such as acylation, alkylation, esterification, amidification to produce structural analogs.

Competitive screening assays may be done by combining KSP and
5 a drug candidate in a first sample. A second sample comprises a mitotic agent, KSP and a drug candidate. This may be performed in either the presence or absence of microtubules. The binding of the drug candidate is determined for both samples, and a change, or difference in binding between the two samples indicates the presence of an agent capable of binding to KSP and potentially modulating its activity. That is, if
10 the binding of the drug candidate is different in the second sample relative to the first sample, the drug candidate is capable of binding to KSP.

In a preferred embodiment, the binding of the candidate agent is determined through the use of competitive binding assays. In this embodiment, the competitor is a binding moiety known to bind to KSP, such as an antibody, peptide,
15 binding partner, ligand, etc. Under certain circumstances, there may be competitive binding as between the candidate agent and the binding moiety, with the binding moiety displacing the candidate agent.

In one embodiment, the candidate agent is labeled. Either the candidate agent, or the competitor, or both, is added first to KSP for a time sufficient
20 to allow binding, if present. Incubations may be performed at any temperature which facilitates optimal activity, typically between about 4 and about 40°C.

Incubation periods are selected for optimum activity, but may also be optimized to facilitate rapid high throughput screening. Typically between 0.1 and 1 hour will be sufficient. Excess reagent is generally removed or washed away.
25 The second component is then added, and the presence or absence of the labeled component is followed, to indicate binding.

In a preferred embodiment, the competitor is added first, followed by the candidate agent. Displacement of the competitor is an indication the candidate agent is binding to KSP and thus is capable of binding to, and potentially modulating,
30 the activity of KSP. In this embodiment, either component can be labeled. Thus, for example, if the competitor is labeled, the presence of label in the wash solution indicates displacement by the agent. Alternatively, if the candidate agent is labeled, the presence of the label on the support indicates displacement.

In an alternative embodiment, the candidate agent is added first, with incubation and washing, followed by the competitor. The absence of binding by the competitor may indicate the candidate agent is bound to KSP with a higher affinity. Thus, if the candidate agent is labeled, the presence of the label on the support,
5 coupled with a lack of competitor binding, may indicate the candidate agent is capable of binding to KSP.

It may be of value to identify the binding site of KSP. This can be done in a variety of ways. In one embodiment, once KSP has been identified as binding to the mitotic agent, KSP is fragmented or modified and the assays repeated
10 to identify the necessary components for binding.

Modulation is tested by screening for candidate agents capable of modulating the activity of KSP comprising the steps of combining a candidate agent with KSP, as above, and determining an alteration in the biological activity of KSP. Thus, in this embodiment, the candidate agent should both bind to KSP (although
15 this may not be necessary), and alter its biological or biochemical activity as defined herein. The methods include both in vitro screening methods and in vivo screening of cells for alterations in cell cycle distribution, cell viability, or for the presence, morphology, activity, distribution, or amount of mitotic spindles, as are generally outlined above.

20 Alternatively, differential screening may be used to identify drug candidates that bind to the native KSP, but cannot bind to modified KSP.

Positive controls and negative controls may be used in the assays. Preferably all control and test samples are performed in at least triplicate to obtain statistically significant results. Incubation of all samples is for a time sufficient for
25 the binding of the agent to the protein. Following incubation, all samples are washed free of non-specifically bound material and the amount of bound, generally labeled agent determined. For example, where a radiolabel is employed, the samples may be counted in a scintillation counter to determine the amount of bound compound.

A variety of other reagents may be included in the screening assays.
30 These include reagents like salts, neutral proteins, e.g., albumin, detergents, etc which may be used to facilitate optimal protein-protein binding and/or reduce non-specific or background interactions. Also reagents that otherwise improve the efficiency of the assay, such as protease inhibitors, nuclease inhibitors, anti-microbial agents, etc., may

These and other aspects of the invention will be apparent from the teachings contained herein.

5

The compounds of the instant invention described in the Examples were tested by the assays described below and were found to have kinase inhibitory activity. Other assays are known in the literature and could be readily performed by those of skill in the art (see, for example, PCT Publication WO 01/30768, May 3, 2001, pages 18-22).

15 Cloning and expression of human poly-histidine tagged KSP motor domain (KSP(367H))

Plasmids for the expression of the human KSP motor domain construct were cloned by PCR using a pBluescript full length human KSP construct (Blangy et al., Cell, vol.83, pp1159-1169, 1995) as a template. The N-terminal primer 5'-GCAACGATTAATATGGCGTCGCAGCCAAATTCGTCTGCGAAG (SEQ.ID.NO.:) and the C-terminal primer 5'-GCAACGCTCGAGTCAGTGAT GATGGTGGTGTGATGCTGATTCACCTTCAGGCTTATTCAATAT (SEQ.ID.NO.:) were used to amplify the motor domain and the neck linker region. The PCR products were digested with AseI and XhoI, ligated into the NdeI/XhoI digestion product of pRSETa (Invitrogen) and transformed into E. coli BL21 (DE3).

Cells were grown at 37°C to an OD₆₀₀ of 0.5. After cooling the culture to room temperature expression of KSP was induced with 100μM IPTG and incubation was continued overnight. Cells were pelleted by centrifugation and washed once with ice-cold PBS. Pellets were flash-frozen and stored -80°C.

30

Protein Purification

Cell pellets were thawed on ice and resuspended in lysis buffer (50mM K-HEPES, pH 8.0, 250mM KCl, 0.1% Tween, 10mM imidazole, 0.5mM Mg-ATP, 1mM PMSF, 2mM benzimidazole, 1x complete protease inhibitor cocktail (Roche)).

- 5 Cell suspensions were incubated with 1mg/ml lysozyme and 5mM β -mercaptoethanol on ice for 10 minutes, followed by sonication (3x 30sec). All subsequent procedures were performed at 4°C. Lysates were centrifuged at 40,000x g for 40 minutes. Supernatants were diluted and loaded onto an SP Sepharose column (Pharmacia, 5ml cartridge) in buffer A (50mM K-HEPES, pH 6.8, 1mM MgCl₂, 1mM EGTA,
- 10 10 μ M Mg-ATP, 1mM DTT) and eluted with a 0 to 750mM KCl gradient in buffer A. Fractions containing KSP were pooled and incubated with Ni-NTA resin (Qiagen) for one hour. The resin was washed three times with buffer B (Lysis buffer minus PMSF and protease inhibitor cocktail), followed by three 15-minute incubations and washes with buffer B. Finally, the resin was incubated and washed for 15 minutes three times
- 15 with buffer C (same as buffer B except for pH 6.0) and poured into a column. KSP was eluted with elution buffer (identical to buffer B except for 150mM KCl and 250mM imidazole). KSP-containing fractions were pooled, made 10% in sucrose, and stored at -80°C.

Microtubules are prepared from tubulin isolated from bovine brain.

- 20 Purified tubulin (> 97% MAP-free) at 1 mg/ml is polymerized at 37°C in the presence of 10 μ M paclitaxel, 1 mM DTT, 1 mM GTP in BRB80 buffer (80 mM K-PIPES, 1 mM EGTA, 1 mM MgCl₂ at pH 6.8). The resulting microtubules are separated from non-polymerized tubulin by ultracentrifugation and removal of the supernatant. The pellet, containing the microtubules, is gently resuspended in 10 μ M paclitaxel, 1 mM
- 25 DTT, 50 μ g/ml ampicillin, and 5 μ g/ml chloramphenicol in BRB80.

- The kinesin motor domain is incubated with microtubules, 1 mM ATP (1:1 MgCl₂: Na-ATP), and compound at 23°C in buffer containing 80 mM K-HEPES (pH 7.0), 1 mM EGTA, 1 mM DTT, 1 mM MgCl₂, and 50 mM KCl. The reaction is terminated by a 2-10 fold dilution with a final buffer composition of 80 mM HEPES
- 30 and 50 mM EDTA. Free phosphate from the ATP hydrolysis reaction is measured via a quinaldine red/ammonium molybdate assay by adding 150 μ l of quench C buffer containing a 2:1 ratio of quench A:quench B. Quench A contains 0.1 mg/ml quinaldine red and 0.14% polyvinyl alcohol; quench B contains 12.3 mM ammonium molybdate tetrahydrate in 1.15 M sulfuric acid. The reaction is incubated for 10

minutes at 23°C, and the absorbance of the phospho-molybdate complex is measured at 540 nm.

The compounds 1-7, 2-1, 3-3 and 4-5 and the compounds shown in Table 1 in the Examples were tested in the above assay and found to have an $IC_{50} \leq 50 \mu M$.

II. Cell Proliferation Assay

Cells are plated in 96-well tissue culture dishes at densities that allow for logarithmic growth over the course of 24, 48, and 72 hours and allowed to adhere overnight. The following day, compounds are added in a 10-point, one-half log titration to all plates. Each titration series is performed in triplicate, and a constant DMSO concentration of 0.1% is maintained throughout the assay. Controls of 0.1% DMSO alone are also included. Each compound dilution series is made in media without serum. The final concentration of serum in the assay is 5% in a 200 μL volume of media. Twenty microliters of Alamar blue staining reagent is added to each sample and control well on the titration plate at 24, 48, or 72 hours following the addition of drug and returned to incubation at 37°C. Alamar blue fluorescence is analyzed 6-12 hours later on a CytoFluor II plate reader using 530-560 nanometer wavelength excitation, 590 nanometer emission.

A cytotoxic EC_{50} is derived by plotting compound concentration on the x-axis and average percent inhibition of cell growth for each titration point on the y-axis. Growth of cells in control wells that have been treated with vehicle alone is defined as 100% growth for the assay, and the growth of cells treated with compounds is compared to this value. Proprietary in-house software is used to calculate percent cytotoxicity values and inflection points using logistic 4-parameter curve fitting. Percent cytotoxicity is defined as:

$$\% \text{ cytotoxicity} = \frac{(\text{Fluorescence}_{\text{control}}) - (\text{Fluorescence}_{\text{sample}})}{(\text{Fluorescence}_{\text{control}})} \times 100$$

The inflection point is reported as the cytotoxic EC_{50} .

III. Evaluation of mitotic arrest and apoptosis by FACS

FACS analysis is used to evaluate the ability of a compound to arrest cells in mitosis and to induce apoptosis by measuring DNA content in a treated population of cells. Cells are seeded at a density of 1.4×10^6 cells per 6 cm^2 tissue culture dish and allowed to adhere overnight. Cells are then treated with vehicle

(0.1% DMSO) or a titration series of compound for 8-16 hours. Following treatment, cells are harvested by trypsinization at the indicated times and pelleted by centrifugation. Cell pellets are rinsed in PBS and fixed in 70% ethanol and stored at 4°C overnight or longer.

5 For FACS analysis, at least 500,000 fixed cells are pelleted and the 70% ethanol is removed by aspiration. Cells are then incubated for 30 min at 4°C with RNase A (50 Kunitz units/ml) and propidium iodide (50 µg/ml), and analyzed using a Becton Dickinson FACSCaliber. Data (from 10,000 cells) is analyzed using the Modfit cell cycle analysis modeling software (Verity Inc.).

10 An EC₅₀ for mitotic arrest is derived by plotting compound concentration on the x-axis and percentage of cells in the G2/M phase of the cell cycle for each titration point (as measured by propidium iodide fluorescence) on the y-axis. Data analysis is performed using the SigmaPlot program to calculate an inflection point using logistic 4-parameter curve fitting. The inflection point is reported as the
15 EC₅₀ for mitotic arrest. A similar method is used to determine the compound EC₅₀ for apoptosis. Here, the percentage of apoptotic cells at each titration point (as determined by propidium iodide fluorescence) is plotted on the y-axis, and a similar analysis is carried out as described above.

20 VI. Immunofluorescence Microscopy to Detect Monopolar Spindles

Methods for immunofluorescence staining of DNA, tubulin, and pericentrin are essentially as described in Kapoor *et al.* (2000) *J. Cell Biol.* **150**: 975-988. For cell culture studies, cells are plated on tissue-culture treated glass chamber slides and allowed to adhere overnight. Cells are then incubated with the
25 compound of interest for 4 to 16 hours. After incubation is complete, media and drug are aspirated and the chamber and gasket are removed from the glass slide. Cells are then permeabilized, fixed, washed, and blocked for nonspecific antibody binding according to the referenced protocol. Paraffin-embedded tumor sections are deparaffinized with xylene and rehydrated through an ethanol series prior to
30 blocking. Slides are incubated in primary antibodies (mouse monoclonal anti-α-tubulin antibody, clone DM1A from Sigma diluted 1:500; rabbit polyclonal anti-pericentrin antibody from Covance, diluted 1:2000) overnight at 4°C. After washing, slides are incubated with conjugated secondary antibodies (FITC-conjugated donkey anti-mouse IgG for tubulin; Texas red-conjugated donkey anti-rabbit IgG for

pericentrin) diluted to 15 μ g/ml for one hour at room temperature. Slides are then washed and counterstained with Hoechst 33342 to visualize DNA. Immunostained samples are imaged with a 100x oil immersion objective on a Nikon epifluorescence microscope using Metamorph deconvolution and imaging software.

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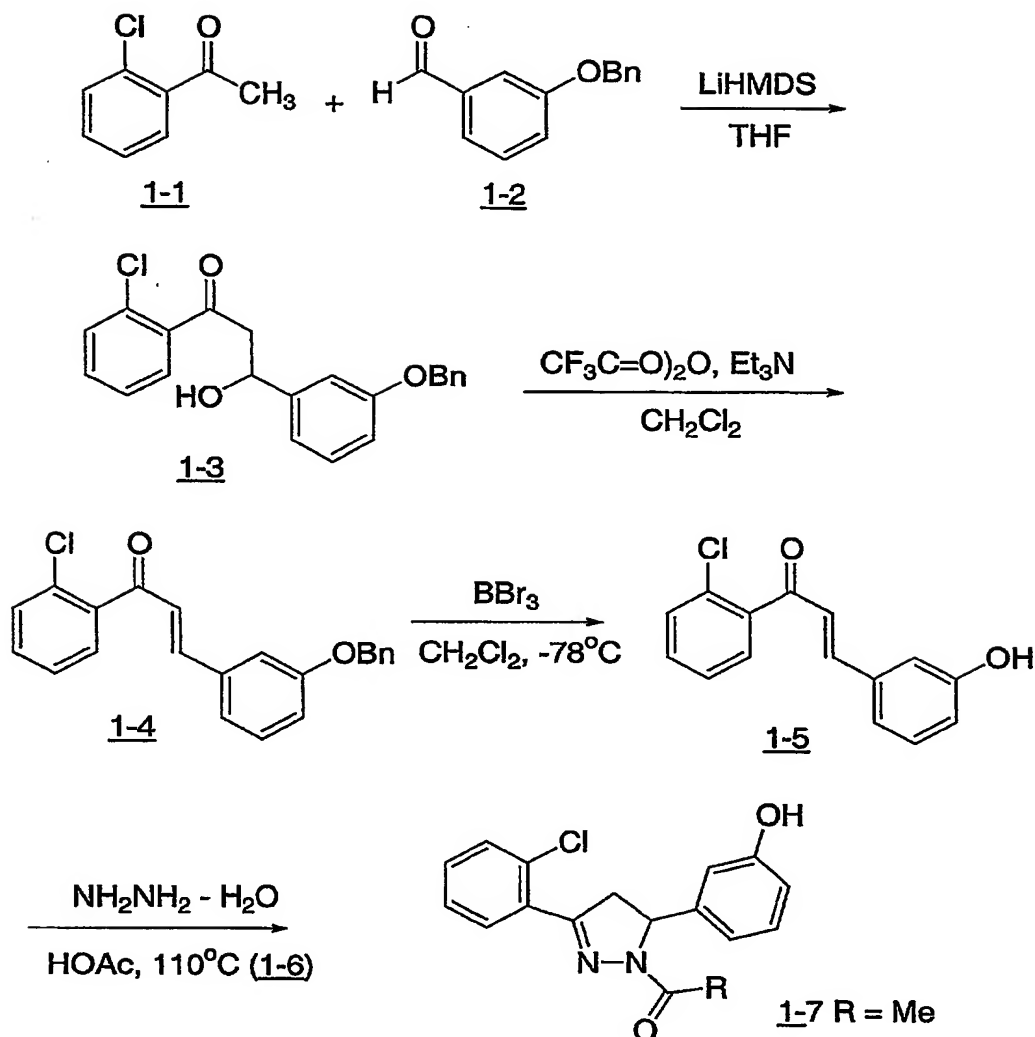
EXAMPLES

Examples provided are intended to assist in a further understanding of the invention. Particular materials employed, species and conditions are intended to be illustrative of the invention and not limiting of the reasonable scope thereof.

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SCHEME 1



5

Step 1: 3-[3-(benzyloxy)phenyl]-1-(2-chlorophenyl)prop-2-en-1-one (1-4)

To a solution of 2'-chloroacetophenone (1-1) (1.26mL, 9.70mmol) in 40 mL of THF at -78°C was slowly added 10.7 mL (10.7mmol) of a 1M LiHMDS solution in THF. After stirring for 1h at -78°C , a solution of 2.05g (9.70mmol) of 3-benzyloxy-benzaldehyde (1-2) in 8 mL of THF was added, and stirring was continued at that temperature for an additional hour. The mixture was then dumped into a

separatory funnel containing 100 mL of saturated aqueous NH_4Cl and extracted twice with 100 mL of EtOAc. The organic phases were combined, washed with 100 mL of brine, and dried over Na_2SO_4 . After filtering off the drying agent, the solvent was removed on a rotary evaporator, and the residue was dissolved in 50 mL of CH_2Cl_2 .

- 5 After cooling to -78°C , 4 mL of triethylamine and 2 mL of trifluoroacetic anhydride were added sequentially, and the mixture was allowed to warm to rt and stir for 12h. The reaction was then dumped into a separatory funnel with 100 mL of 1M HCl, the layers were separated, and the aqueous phase extracted again with CH_2Cl_2 . The organic layers were combined, washed again with 1 M HCl, washed with water, and dried over Na_2SO_4 . After concentration, the crude material was purified by chromatography on silica gel with a gradient of 0 to 40% EtOAc in hexanes over 45 min to provide 1-4 as a viscous yellow oil. Data for 1-4: $^1\text{HNMR}$ (500 MHz, CDCl_3) δ 7.5 – 7.0 (m, 15H) 5.1 (s, 2H) ppm.

- 15 Step 1: 1-(2-chlorophenyl)-3-(hydroxyphenyl)prop-2-en-1-one (1-5)

To a solution of 740 mg (2.12mmol) of 1-4 in 15 mL of CH_2Cl_2 at -78°C was added dropwise 2.75 mL (2.75mmol) of a 1M solution of BBr_3 in CH_2Cl_2 . After stirring for 30 min at that temperature, 1 mL of MeOH was added, and the mixture was dumped into water, extracted twice with 50 mL of CH_2Cl_2 , washed again with water, and dried over Na_2SO_4 . After concentration, the residue was purified by column chromatography on silica gel with a gradient of 2 to 70% EtOAc in hexanes over 30 min to provide 1-5 as a beige solid. Data for 1-5: $^1\text{HNMR}$ (500 MHz, CDCl_3) δ 7.5 – 7.3 (m, 5H), 7.25 (m, 1H), 7.2 – 7.0 (m, 3H), 6.9 (m, 1H), 5.1 (bs, 1H) ppm.

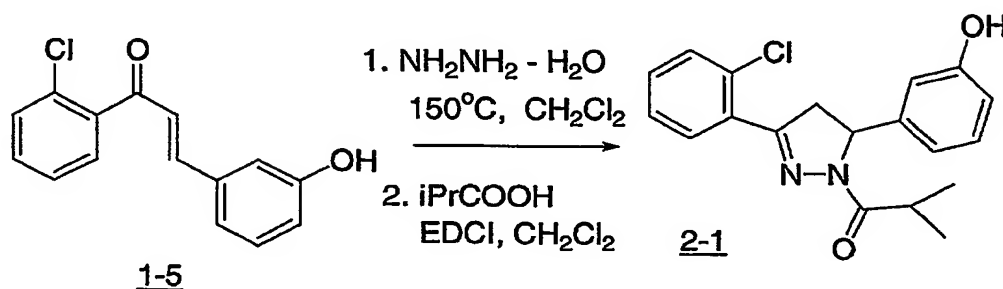
- 25 Step 1: 3-[1-acetyl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol (1-7)

To a solution of 120mg (0.46mmol) of chalcone 1-5 in 4 mL of acetic acid was added 50 μL (0.93mmol) of hydrazine hydrate. The reaction was then placed in an oil bath at 110°C for 24h. After cooling to rt, the solvents were removed on a rotary evaporator, the residue was dissolved in 50 mL of CH_2Cl_2 , washed twice with aqueous NaHCO_3 , dried over Na_2SO_4 , and concentrated. The residue was then purified by column chromatography on silica gel with a gradient of 5 to 75% EtOAc in hexanes over 30 min to provide 1-7 as a fluffy white solid. Data for 1-7: $^1\text{HNMR}$ (500 MHz, CDCl_3) δ 7.75 (m, 1H), 7.45 (m 1H), 7.4 – 7.3 (m, 2H), 7.2 (m, 1H), 6.8

(d, 1H), 6.7 (m, 2H), 5.5 (m, 1H), 3.9 (m, 1H), 3.3 (m, 1H), 2.4 (s, 3H) ppm. HRMS (ES) calc'd M + H for $C_{17}H_{15}ClN_2O_2$: 315.0895. Found: 315.0904.

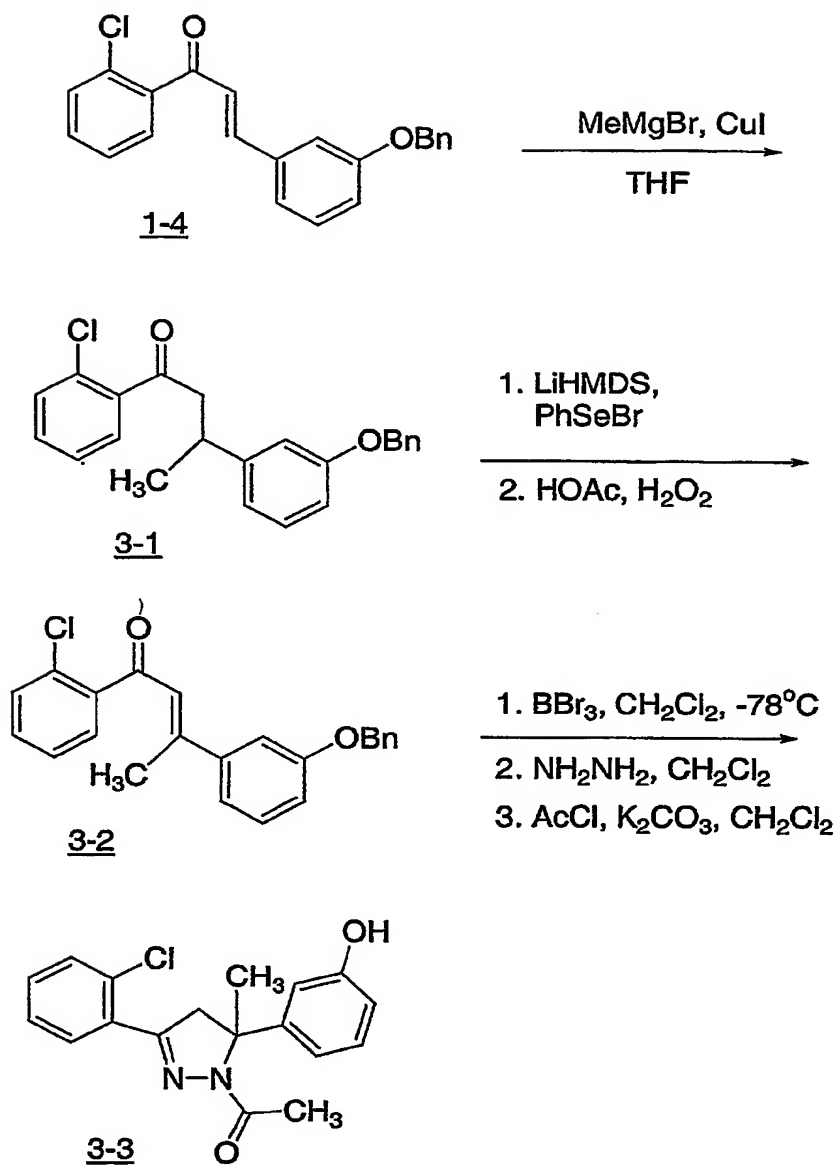
SCHEME 2

5



3-[3-(2-chlorophenyl)-1-isobutyryl-4,5-dihydro-1H-pyrazol-5-yl]phenol (2-1)

To a solution of 150mg (0.58mmol) of chalcone **1-5** in 4 mL of CH_2Cl_2 was added 30 μL (0.64mmol) of hydrazine hydrate. The mixture was then heated in a microwave reactor at $150^\circ C$ for 5 min. After cooling to $0^\circ C$, 268 μL (2.9mmol) of isobutyric acid was added, followed by 135 mg (0.70mmol) of EDCI (1-[3-(dimethylamino)propyl]-3-ethylcarbodiimide hydrochloride). The reaction was then warmed to rt and allowed to stir for 18h. The mixture was dumped into a separatory funnel, washed twice with 10% aqueous citric acid, twice with $NaHCO_3$, dried over Na_2SO_4 , and concentrated. The residue was purified by column chromatography on silica gel with a gradient of 0 to 75% EtOAc in hexanes over 30 min to provide **2-1** as a pale orange film. Data for **2-1**: 1H NMR (500 MHz, $CDCl_3$) δ 7.7 (m, 1H), 7.45 (m, 1H), 7.3 (m, 2H), 7.1 (m, 1H), 6.7 (m, 2H), 6.65 (m, 1H), 6.55 (bs, 1H), 5.5 (m, 1H), 3.9 (m, 1H), 3.5 (m, 1H), 3.3 (m, 1H), 1.3 (m, 6H) ppm. HRMS (ES) calc'd M + H for $C_{19}H_{19}ClN_2O_2$: 343.1208. Found: 342.1213.

SCHEME 35 3-[1-acetyl-3-(2-chlorophenyl)-5-methyl-4,5-dihydro-1H-pyrazol-5-yl]phenol (3-3)

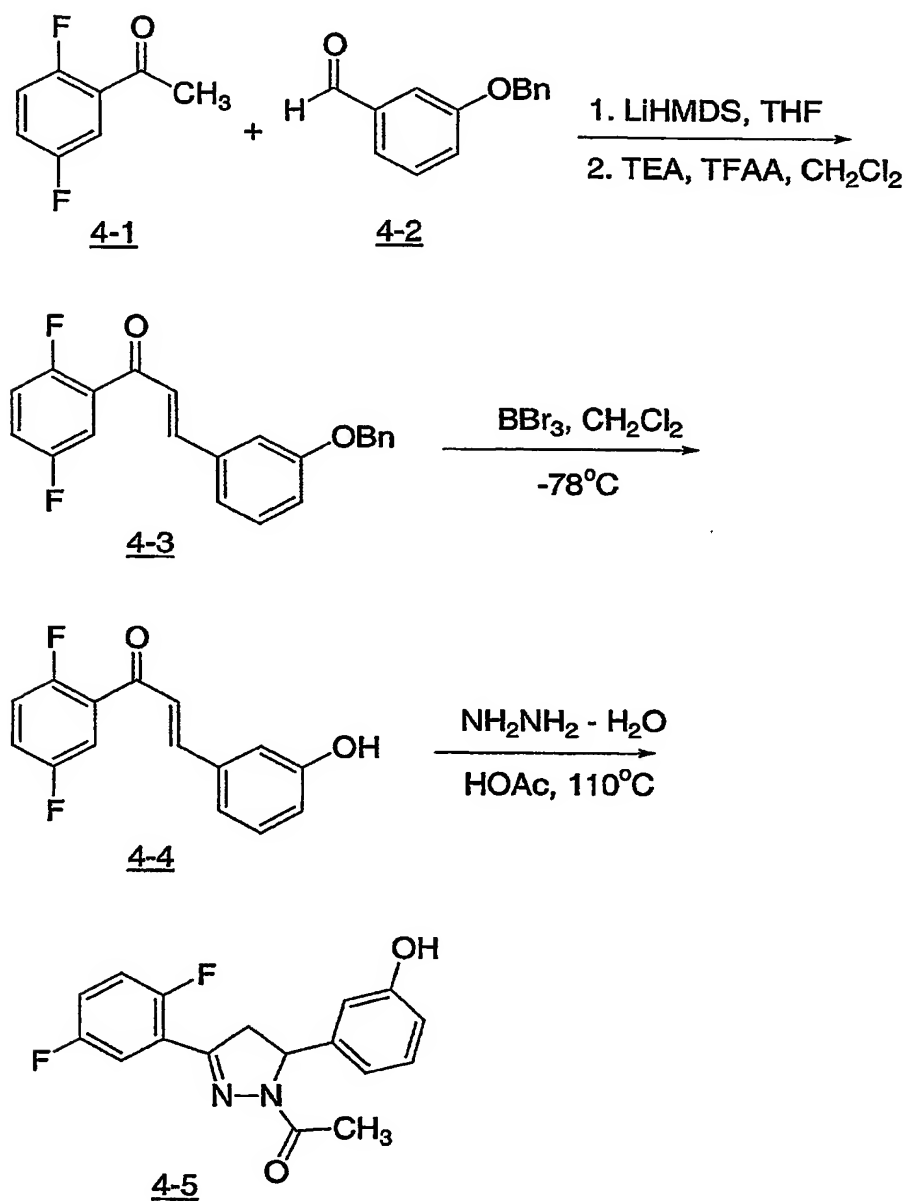
To a suspension of CuI (721 mg, 3.78mmol) in 15mL of THF at -78°C was added 2.52 mL (7.57mmol) of a 3M solution of MeMgBr in Et₂O. The mixture

was stirred for 30 min, warmed slowly to -30°C , cooled back to -78°C , and a solution of 1.2 g (3.44mmol) of chalcone 1-4 in 10 mL of THF was added dropwise. The reaction was then warmed to 0°C and stirred for 30 min, at which time TLC analysis indicated complete reaction. After carefully quenching with saturated NH_4Cl , the mixture was extracted twice with EtOAc, washed with brine, and dried over Na_2SO_4 . Following concentration, the product was purified by chromatography on silica gel with a gradient of 0 to 45% EtOAc in hexanes over 45 min to provide 3-1 as a yellow oil, contaminated with a significant amount of another compound assumed to be the 1,2-addition product. This crude material was then dissolved in 15mL of THF, cooled to -78°C , and 2.26mL (2.26mmol) of a 1M solution of LiHMDS in THF was added dropwise. After stirring for 1h, a solution of 535mg (2.26mmol) of PhSeBr in 2 mL of THF was added, and stirring was continued for 30 min. The reaction was then dumped into saturated NH_4Cl , extracted twice with EtOAc, washed with brine and dried. This crude material was dissolved in 15mL of Et_2O , and after the addition of 2 mL of H_2O and 500 μL of HOAc, 2 mL of 30% aqueous H_2O_2 was added and the mixture was stirred for 20 min. The mixture was then dumped into a separatory funnel with saturated aqueous NaHCO_3 , extracted twice with Et_2O , washed with brine, and dried over MgSO_4 . After concentration, the crude material was purified by chromatography on silica gel with a gradient of 0 to 35% EtOAc in hexanes over 45 min to provide 3-2 as a yellow oil, which was characterized only by LC-MS to have the desired $m/z = 362$. To 50 mg (0.14mmol) of 3-2 dissolved in 5 mL of CH_2Cl_2 at -78°C was added 210 μL (0.21mmol) of a 1M solution of BBR_3 in CH_2Cl_2 . After stirring for 20 min, 500 μL of MeOH was added, and the resultant mixture was dumped into water, extracted twice with CH_2Cl_2 , washed twice with water, and dried over Na_2SO_4 . After concentration, this material was dissolved in 2.5 mL of CH_2Cl_2 , 22 μL (0.45mmol) of hydrazine hydrate was added, and the mixture was heated at 150°C in a microwave reactor for 5 min. After cooling the reaction to -78°C , 210 mg (1.5mmol) of K_2CO_3 and 54 μL (0.75mmol) of acetyl chloride were added, and the reaction was allowed to warm to rt and stir for 12h. The mixture was then dumped into a separatory funnel with 10% aqueous citric acid, extracted twice with CH_2Cl_2 , washed with NaHCO_3 , and dried over Na_2SO_4 . After concentration, the residue was purified by column chromatography on silica gel with a gradient of 2 to 75% EtOAc in hexanes over 45 min to provide 3-3 as an off-white taffy. Data for 3-3: ^1H NMR (500 MHz, CDCl_3) δ 7.7 (m, 1H), 7.4 (m, 1H), 7.3 (m, 2H), 7.1 (m, 1H), 6.8 (m, 1H),

6.7 (m, 1H), 6.6 (m, 1H), 5.9 (s, 1H), 3.6 (m, 2H), 2.4 (s, 3H), 2.0 (s, 3H) ppm.
 HRMS (ES) calc'd M + H for $C_{18}H_{17}ClN_2O_2$: 329.1051. Found: 329.1045.

SCHEME 4

5



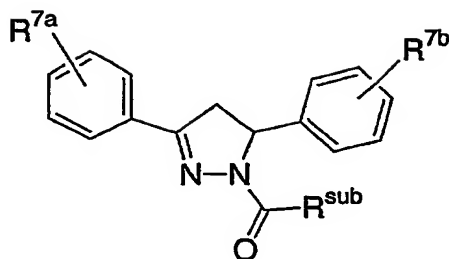
3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol (6-5)

Compound 4-5 was prepared starting from 2,5-difluoroacetophenone
5 (4-1, available in bulk from Marshallton Research Laboratories) and 3-benzyloxybenzaldehyde (4-2) by a process analogous to that described in Scheme 1 for 1-7. Data for 4-5: ¹HNMR (500 MHz, CDCl₃) δ 7.85 (m, 1H), 7.2 – 7.0 (m, 3H), 6.8 (m, 1H), 6.7 (m, 2H), 5.5 (m, 1H), 5.3 (s, 1H), 3.8 (m, 1H), 3.3 (m, 1H), 2.4 (s, 3H) ppm. HRMS (FT/ICR) calc'd M + H for C₁₇H₁₄F₂N₂O₂: 317.1096. Found:
10 317.1108.

Chiral resolution of racemic 4-5 was achieved by HPLC
chromatography (Chiralcel AD 5 x 50 cm column; eluting with 80% hexanes (+0.1 %
TFA)/20% ethanol at 75 mL/min) to give the faster eluting (+)-enantiomer R_T = 20.7
15 min and slower eluting(-)-enantiomer R_T = 34.5 min.

The compounds of the invention illustrated below in Table 1 were
prepared by the synthetic methods described hereinabove, but substituting the
appropriate acetophenones, phenyl aldehydes and carboxylic acids for the
20 corresponding reagents utilized in the above examples:

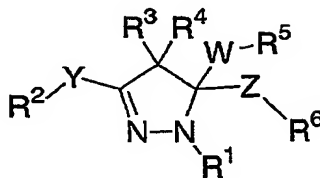
TABLE 1



R^{sub}	R^{7a}	R^{7b}	HRMS (calc'd)	HRMS (found)
CH_3	2-F	3-OH	299.1191	299.1195
CH_3	3-Br	3-OH	359.0390	359.0399
CH_3	2,3-diCl	3-OH	349.0505	349.0506
CH_3	2,5-diCl	3-OH	349.0505	349.0511
Et	2-Cl	3-OH	329.1052	329.1055
i-Pr	2-Cl	3-OH	343.1208	343.1213
CH_3	2-Cl	H	299.0946	299.0949
CH_3	3-Cl	H	299.0946	299.0954
CH_3	2, 5-diF	H	301.1147	301.1154
CH_3	2, 5-diF	4-F, 3-OH	335.1002	335.1006

WHAT IS CLAIMED IS:

1. A compound of Formula I:



I

or a pharmaceutically acceptable salt or stereoisomer thereof, wherein

- a is 0 or 1;
 b is 0 or 1;
 10 m is 0, 1, or 2;
 n is 0 to 2;
 u is 2, 3, 4 or 5;

R¹ is selected from:

- 15 1) (C=X)C₁-C₁₀ alkyl,
 2) (C=X)aryl,
 3) (C=X)C₂-C₁₀ alkenyl,
 4) (C=X)C₂-C₁₀ alkynyl,
 5) (C=X)C₃-C₈ cycloalkyl,
 20 6) (C=X)heterocyclyl,
 7) (C=X)NR⁷R⁸,
 8) (C=X)OC₁-C₁₀ alkyl,
 9) SO₂NR⁷R⁸,
 10) SO₂C₁-C₁₀ alkyl,
 25 11) SO₂C₁-C₁₀ aryl,
 12) SO₂C₁-C₁₀ heterocyclyl,
 13) C₁-C₁₀ alkyl,
 14) aryl,
 15) heteroaryl,

- 16) $(\text{CH}_2)_u(\text{C}=\text{O})\text{C}_1\text{-C}_{10}$ alkyl,
- 17) $(\text{CH}_2)_u(\text{C}=\text{O})\text{NR}^7\text{R}^8$,
- 18) 3-pyrrolidinonyl, 3-piperidinonyl, 2-cyclopentanonyl, 2-cyclohexanonyl,
- 5 19) $(\text{C}=\text{O})(\text{C}=\text{O})\text{C}_1\text{-C}_{10}$ alkyl,
- 20) $(\text{C}=\text{O})(\text{C}=\text{O})\text{NR}^7\text{R}^8$,
- 21) $(\text{C}=\text{O})(\text{C}=\text{O})\text{O C}_1\text{-C}_{10}$ alkyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, heteroaryl and heterocyclyl is optionally substituted with one or more substituents selected from R^7 ; or

10 R^2 is selected from:

- 1) $\text{C}_1\text{-C}_{10}$ alkyl,
- 2) aryl,
- 3) $\text{C}_2\text{-C}_{10}$ alkenyl,
- 15 4) $\text{C}_2\text{-C}_{10}$ alkynyl,
- 5) $\text{C}_1\text{-C}_6$ perfluoroalkyl,
- 6) $\text{C}_1\text{-C}_6$ aralkyl,
- 7) $\text{C}_1\text{-C}_6$ heteroaralkyl,
- 8) $\text{C}_3\text{-C}_8$ cycloalkyl, and
- 20 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl, heteroaralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R^7 ;

R^3 , R^4 , R^5 and R^6 are independently selected from:

- 25 1) H,
- 2) $\text{C}_1\text{-C}_{10}$ alkyl,
- 3) aryl,
- 4) $\text{C}_2\text{-C}_{10}$ alkenyl,
- 5) $\text{C}_2\text{-C}_{10}$ alkynyl,
- 30 6) $\text{C}_1\text{-C}_6$ perfluoroalkyl,
- 7) $\text{C}_1\text{-C}_6$ aralkyl,
- 8) $\text{C}_3\text{-C}_8$ cycloalkyl, and
- 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; or

- 5 R³ and R⁴, or R⁵ and R⁶, attached to the same carbon atom (W and Z are a bond) are combined to form $-(CH_2)_n-$ wherein one of the carbon atoms is optionally replaced by a moiety selected from O, S(O)_m, -N(R⁹)C(O)-, and -N(COR¹⁰)-;

R⁷ is:

- | | | |
|----|-----|------------------------------------------------------------------------------|
| | 1) | (C=O) _a O _b C ₁ -C ₁₀ alkyl, |
| 10 | 2) | (C=O) _a O _b aryl, |
| | 3) | C ₂ -C ₁₀ alkenyl, |
| | 4) | C ₂ -C ₁₀ alkynyl, |
| | 5) | (C=O) _a O _b heterocyclyl, |
| | 6) | CO ₂ H, |
| 15 | 7) | halo, |
| | 8) | CN, |
| | 9) | OH, |
| | 10) | O _b C ₁ -C ₆ perfluoroalkyl, |
| | 11) | O _a (C=O) _b NR ⁹ R ¹⁰ , |
| 20 | 12) | S(O) _m R ^a , |
| | 13) | S(O) ₂ NR ⁹ R ¹⁰ , |
| | 14) | oxo, |
| | 13) | CHO, |
| | 14) | (N=O)R ⁹ R ¹⁰ , or |
| 25 | 15) | (C=O) _a O _b C ₃ -C ₈ cycloalkyl, |

said alkyl, aryl, alkenyl, alkynyl, heterocyclyl, and cycloalkyl optionally substituted with one or more substituents selected from R⁸;

R⁸ is selected from:

- | | | |
|----|----|----------------------------------------------------------------------------------------------------------------------|
| 30 | 1) | (C=O) _r O _s (C ₁ -C ₁₀)alkyl, wherein r and s are independently 0 or 1, |
| | 2) | O _r (C ₁ -C ₃)perfluoroalkyl, wherein r is 0 or 1, |
| | 3) | (C ₀ -C ₆)alkylene-S(O) _m R ^a , wherein m is 0, 1, or 2, |
| | 4) | oxo, |
| | 5) | OH, |

- 6) halo,
- 7) CN,
- 8) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_2\text{-C}_{10})\text{alkenyl}$,
- 9) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_2\text{-C}_{10})\text{alkynyl}$,
- 5 10) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_3\text{-C}_6)\text{cycloalkyl}$,
- 11) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)\text{alkylene-aryl}$,
- 12) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)\text{alkylene-heterocyclyl}$,
- 13) $(\text{C}=\text{O})_r\text{O}_s(\text{C}_0\text{-C}_6)\text{alkylene-N(R}^b)_2$,
- 14) C(O)R^a ,
- 10 15) $(\text{C}_0\text{-C}_6)\text{alkylene-CO}_2\text{R}^a$,
- 16) C(O)H ,
- 17) $(\text{C}_0\text{-C}_6)\text{alkylene-CO}_2\text{H}$,
- 18) $\text{C(O)N(R}^b)_2$,
- 19) $\text{S(O)}_m\text{R}^a$, and
- 15 20) $\text{S(O)}_2\text{NR}^9\text{R}^{10}$,

said alkyl, alkenyl, alkynyl, cycloalkyl, aryl, and heterocyclyl is optionally substituted with up to three substituents selected from R^b , OH, $(\text{C}_1\text{-C}_6)\text{alkoxy}$, halogen, CO_2H , CN, $\text{O}(\text{C}=\text{O})\text{C}_1\text{-C}_6$ alkyl, oxo, and $\text{N(R}^b)_2$;

20 R^9 and R^{10} are independently selected from:

- 1) H,
- 2) $(\text{C}=\text{O})\text{O}_b\text{C}_1\text{-C}_{10}$ alkyl,
- 3) $(\text{C}=\text{O})\text{O}_b\text{C}_3\text{-C}_8$ cycloalkyl,
- 4) $(\text{C}=\text{O})\text{O}_b\text{aryl}$,
- 25 5) $(\text{C}=\text{O})\text{O}_b\text{heterocyclyl}$,
- 6) $\text{C}_1\text{-C}_{10}$ alkyl,
- 7) aryl,
- 8) $\text{C}_2\text{-C}_{10}$ alkenyl,
- 9) $\text{C}_2\text{-C}_{10}$ alkynyl,
- 30 10) heterocyclyl,
- 11) $\text{C}_3\text{-C}_8$ cycloalkyl,
- 12) SO_2R^a , and
- 13) $(\text{C}=\text{O})\text{NR}^b_2$,

said alkyl, cycloalkyl, aryl, heterocyclyl, alkenyl, and alkynyl is optionally substituted with one or more substituents selected from R⁸, or

R⁹ and R¹⁰ can be taken together with the nitrogen to which they are attached to form a monocyclic or bicyclic heterocycle with 5-7 members in each ring and optionally containing, in addition to the nitrogen, one or two additional heteroatoms selected from N, O and S, said monocyclic or bicyclic heterocycle optionally substituted with one or more substituents selected from R⁸;

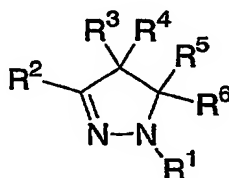
R^a is (C₁-C₆)alkyl, (C₃-C₆)cycloalkyl, aryl, or heterocyclyl; and

R^b is H, (C₁-C₆)alkyl, aryl, heterocyclyl, (C₃-C₆)cycloalkyl, (C=O)OC₁-C₆ alkyl, (C=O)C₁-C₆ alkyl or S(O)₂R^a;

X is selected from O and S;

Y, W and Z are independently selected from: a bond, C=O, C=S, S(O)_n, CH(OH) and O.

2. A compound of the Formula II,



II

wherein:

25

a is 0 or 1;

b is 0 or 1;

m is 0, 1, or 2;

n is 0 to 2;

R¹ is selected from:

- 1) (C=O)C₁-C₁₀ alkyl,
- 2) (C=O)aryl,
- 5 3) (C=O)C₂-C₁₀ alkenyl,
- 4) (C=O)C₂-C₁₀ alkynyl,
- 5) (C=O)C₃-C₈ cycloalkyl,
- 6) (C=O)heterocyclyl,
- 7) (C=O)OC₁-C₁₀ alkyl,
- 10 8) (C=O)NR⁷R⁸,
- 9) SO₂NR⁷R⁸,
- 10) SO₂C₁-C₁₀ alkyl,
- 11) SO₂C₁-C₁₀ aryl,
- 12) SO₂C₁-C₁₀ heterocyclyl,

15 said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, and heterocyclyl is optionally substituted with one or more substituents selected from R⁷; or

R² is selected from:

- 1) C₁-C₁₀ alkyl,
- 20 2) aryl,
- 3) C₂-C₁₀ alkenyl,
- 4) C₂-C₁₀ alkynyl,
- 5) C₁-C₆ perfluoroalkyl,
- 6) C₁-C₆ aralkyl,
- 25 7) C₃-C₈ cycloalkyl, and
- 8) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

30 R³, R⁴, R⁵ and R⁶ are independently selected from:

- 1) H,
- 2) C₁-C₁₀ alkyl,
- 3) aryl,
- 4) C₂-C₁₀ alkenyl,

- 5) C₂-C₁₀ alkynyl,
- 6) C₁-C₆ perfluoroalkyl,
- 7) C₁-C₆ aralkyl,
- 8) C₃-C₈ cycloalkyl, and
- 9) heterocyclyl,

said alkyl, aryl, alkenyl, alkynyl, cycloalkyl, aralkyl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

R⁷ is:

- 1) (C=O)_aO_bC₁-C₁₀ alkyl,
- 2) (C=O)_aO_baryl,
- 3) C₂-C₁₀ alkenyl,
- 4) C₂-C₁₀ alkynyl,
- 5) (C=O)_aO_b heterocyclyl,
- 6) CO₂H,
- 7) halo,
- 8) CN,
- 9) OH,
- 10) O_bC₁-C₆ perfluoroalkyl,
- 11) O_a(C=O)_bNR⁹R¹⁰,
- 12) S(O)_mR^a,
- 13) S(O)₂NR⁹R¹⁰,
- 14) oxo,
- 15) CHO,
- 16) (N=O)R⁹R¹⁰, or
- 17) (C=O)_aO_bC₃-C₈ cycloalkyl,

said alkyl, aryl, alkenyl, alkynyl, heterocyclyl, and cycloalkyl optionally substituted with one, two or three substituents selected from R⁸;

R⁸ is selected from:

- 1) (C=O)_rO_s(C₁-C₁₀)alkyl, wherein r and s are independently 0 or 1,
- 2) O_r(C₁-C₃)perfluoroalkyl, wherein r is 0 or 1,
- 3) oxo,
- 4) OH,

- 5) halo,
 6) CN,
 7) (C₂-C₁₀)alkenyl,
 8) (C₂-C₁₀)alkynyl,
 5 9) (C=O)_rO_s(C₃-C₆)cycloalkyl,
 10) (C=O)_rO_s(C₀-C₆)alkylene-aryl,
 11) (C=O)_rO_s(C₀-C₆)alkylene-heterocyclyl,
 12) (C=O)_rO_s(C₀-C₆)alkylene-N(R^b)₂,
 13) C(O)R^a,
 10 14) (C₀-C₆)alkylene-CO₂R^a,
 15) C(O)H,
 16) (C₀-C₆)alkylene-CO₂H, and
 17) C(O)N(R^b)₂,
 18) S(O)_mR^a, and
 15 19) S(O)₂NR⁹R¹⁰

said alkyl, alkenyl, alkynyl, cycloalkyl, aryl, and heterocyclyl is optionally substituted with up to three substituents selected from R^b, OH, (C₁-C₆)alkoxy, halogen, CO₂H, CN, O(C=O)C₁-C₆ alkyl, oxo, and N(R^b)₂;

R⁹ and R¹⁰ are independently selected from:

- 1) H,
 2) (C=O)O_bC₁-C₁₀ alkyl,
 3) (C=O)O_bC₃-C₈ cycloalkyl,
 25 4) (C=O)O_baryl,
 5) (C=O)O_bheterocyclyl,
 6) C₁-C₁₀ alkyl,
 7) aryl,
 8) C₂-C₁₀ alkenyl,
 30 9) C₂-C₁₀ alkynyl,
 10) heterocyclyl,
 11) C₃-C₈ cycloalkyl,
 12) SO₂R^a, and
 13) (C=O)NR^b₂,

said alkyl, cycloalkyl, aryl, heterocyclyl, alkenyl, and alkynyl is optionally substituted with one, two or three substituents selected from R⁸, or

5 R⁹ and R¹⁰ can be taken together with the nitrogen to which they are attached to form a monocyclic or bicyclic heterocycle with 5-7 members in each ring and optionally containing, in addition to the nitrogen, one or two additional heteroatoms selected from N, O and S, said monocyclic or bicyclic heterocycle optionally substituted with one, two or three substituents selected from R⁸;

10 R^a is (C₁-C₆)alkyl, (C₃-C₆)cycloalkyl, aryl, or heterocyclyl; and

R^b is H, (C₁-C₆)alkyl, aryl, heterocyclyl, (C₃-C₆)cycloalkyl, (C=O)OC₁-C₆ alkyl, (C=O)C₁-C₆ alkyl or S(O)₂R^a.

15 3. The compound according to Claim 2 or a pharmaceutically acceptable salt or stereoisomer thereof, wherein:

R¹ is selected from:

- 20 1) (C=O)C₁-C₁₀ alkyl,
2) (C=O)aryl,
3) (C=O)C₃-C₈ cycloalkyl,
4) (C=O)heterocyclyl,
5) (C=O)OC₁-C₁₀ alkyl,
6) SO₂NR⁷R⁸, and
25 7) SO₂C₁-C₁₀ alkyl,

said alkyl, aryl, cycloalkyl, and heterocyclyl is optionally substituted with one, two or three substituents selected from R⁷;

R² is selected from:

- 30 1) C₁-C₁₀ alkyl,
2) aryl, and
3) heteroaryl,

said alkyl, aryl and heteroaryl is optionally substituted with one or more substituents selected from R⁷;

R³ and R⁴ are independently selected from:

- 1) H, and
- 2) C₁-C₁₀ alkyl,

5 said alkyl is optionally substituted with one or more substituents selected from R⁷; and

R⁵ and R⁶ are independently selected from:

- 1) H,
- 10 2) C₁-C₁₀ alkyl,
- 3) aryl, and
- 4) heterocyclyl,

said alkyl, aryl and heterocyclyl is optionally substituted with one or more substituents selected from R⁷;

15

and R⁷, R⁸, R⁹, R¹⁰, R^a and R^b are as described in Claim 2.

4. The compound according to Claim 3, or the pharmaceutically acceptable salt or stereoisomer thereof, wherein R² is phenyl, optionally substituted
20 with one or two substituents selected from R⁷.

5. A compound selected from:

25 3-[1-acetyl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[3-(2-chlorophenyl)-1-isobutyryl-4,5-dihydro-1H-pyrazol-5-yl]phenol

3-[1-acetyl-3-(2-chlorophenyl)-5-methyl-4,5-dihydro-1H-pyrazol-5-yl]phenol

30 3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

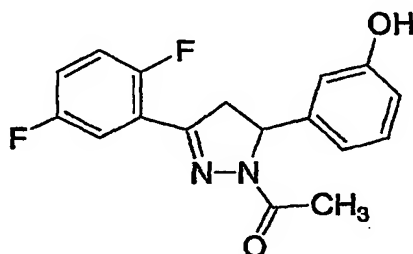
(+)-3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

(-)-3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol

- 3-[1-Acetyl-3-(2-fluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 3-[1-Acetyl-3-(3-bromophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 5 3-[1-Acetyl-3-(2,3-dichlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 3-[1-Acetyl-3-(2,5-dichlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 10 3-[1-Propionyl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 3-[1-Isobutyryl-3-(2-chlorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol
- 1-Acetyl-3-(2-chlorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole
- 15 1-Acetyl-3-(3-chlorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole
- 1-Acetyl-3-(2,5-difluorophenyl)-5-phenyl-4,5-dihydro-1H-pyrazole
- 20 1-Acetyl-3-(4-fluoro-3-hydroxyphenyl)-5-phenyl-4,5-dihydro-1H-pyrazole
- or a pharmaceutically acceptable salt or stereoisomer thereof.

6. The compound according to Claim 5 which is

- 25 3-[1-acetyl-3-(2,5-difluorophenyl)-4,5-dihydro-1H-pyrazol-5-yl]phenol



or a pharmaceutically acceptable salt or stereoisomer thereof.

7. A pharmaceutical composition that is comprised of a compound in accordance with Claim 1 and a pharmaceutically acceptable carrier.

5

8. A method of treating or preventing cancer in a mammal in need of such treatment that is comprised of administering to said mammal a therapeutically effective amount of a compound of Claim 1.

10

9. A method of treating cancer or preventing cancer in accordance with Claim 8 wherein the cancer is selected from cancers of the brain, genitourinary tract, lymphatic system, stomach, larynx and lung.

15

10. A method of treating or preventing cancer in accordance with Claim 8 wherein the cancer is selected from histiocytic lymphoma, lung adenocarcinoma, small cell lung cancers, pancreatic cancer, glioblastomas and breast carcinoma.

20

11. A process for making a pharmaceutical composition which comprises combining a compound of Claim 1 with a pharmaceutically acceptable carrier.

12. The composition of Claim 7 further comprising a second compound selected from:

25

- 1) an estrogen receptor modulator,
- 2) an androgen receptor modulator,
- 3) retinoid receptor modulator,
- 4) a cytotoxic agent,
- 5) an antiproliferative agent,
- 30 6) a prenyl-protein transferase inhibitor,
- 7) an HMG-CoA reductase inhibitor,

- 8) an HIV protease inhibitor,
- 9) a reverse transcriptase inhibitor,
- 10) an angiogenesis inhibitor, and
- 11) a PPAR- γ agonist..

5

13. The composition of Claim 12, wherein the second compound is an angiogenesis inhibitor selected from the group consisting of a tyrosine kinase inhibitor, an inhibitor of epidermal-derived growth factor, an inhibitor of fibroblast-derived growth factor, an inhibitor of platelet derived growth factor, an MMP
10 inhibitor, an integrin blocker, interferon- α , interleukin-12, pentosan polysulfate, a cyclooxygenase inhibitor, carboxyamidotriazole, combretastatin A-4, squalamine, 6-O-(chloroacetyl-carbonyl)-fumagillol, thalidomide, angiostatin, troponin-1, and an antibody to VEGF.

14. The composition of Claim 13, wherein the second compound is
15 an estrogen receptor modulator selected from tamoxifen and raloxifene.

15. A method of treating cancer which comprises administering a
therapeutically effective amount of a compound of Claim 1 in combination with
20 radiation therapy.

16. A method of treating or preventing cancer that comprises
administering a therapeutically effective amount of a compound of Claim 1 in
combination with a compound selected from:

- 25 1) an estrogen receptor modulator,
- 2) an androgen receptor modulator,
- 3) retinoid receptor modulator,
- 4) a cytotoxic agent,
- 5) an antiproliferative agent,
- 30 6) a prenyl-protein transferase inhibitor,

- 7) an HMG-CoA reductase inhibitor,
- 8) an HIV protease inhibitor,
- 9) a reverse transcriptase inhibitor, and
- 10) an angiogenesis inhibitor.

5

17. A method of treating cancer that comprises administering a therapeutically effective amount of a compound of Claim 1 in combination with radiation therapy and a compound selected from:

- 1) an estrogen receptor modulator,
- 2) an androgen receptor modulator,
- 3) retinoid receptor modulator,
- 4) a cytotoxic agent,
- 5) an antiproliferative agent,
- 6) a prenyl-protein transferase inhibitor,
- 7) an HMG-CoA reductase inhibitor,
- 8) an HIV protease inhibitor,
- 9) a reverse transcriptase inhibitor, and
- 10) an angiogenesis inhibitor.

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15

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18. A method of treating or preventing cancer which comprises administering a therapeutically effective amount of a compound of Claim 1 and paclitaxel or trastuzumab.

25

19. A method of treating or preventing cancer which comprises administering a therapeutically effective amount of a compound of Claim 1 and a GPIIb/IIIa antagonist.

30

20. The method of Claim 18 wherein the GPIIb/IIIa antagonist is tirofiban.

21. A method of treating or preventing cancer which comprises administering a therapeutically effective amount of a compound of Claim 1 in combination with a COX-2 inhibitor.

5 22. A method of modulating mitotic spindle formation which comprises administering a therapeutically effective amount of a compound of Claim 1.

10 23. A method of inhibiting the mitotic kinesin KSP which comprises administering a therapeutically effective amount of a compound of Claim 1.

TITLE OF THE INVENTION

MITOTIC KINESIN INHIBITORS

ABSTRACT OF THE DISCLOSURE

- 5 The present invention relates to dihydropyrazole compounds that are useful for treating cellular proliferative diseases, for treating disorders associated with KSP kinesin activity, and for inhibiting KSP kinesin. The invention also related to compositions which comprise these compounds, and methods of using them to treat cancer in mammals.
- 10

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